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Marshall Laboratory

Research Report

THE EFFECT OF VARIATIONS IN PIGMENT PACKING ON THE PROPERTIES OF EMULSION PAINTS

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THE EFFECT OF VARIATIONS IN PIGMENT PACKING ON THE PROPERTIES OF EMULSION PAINTS

TABLE OF CONTENTS

LIST OF TABLES

(SEE ATTACHED PAGE)

LIST OF TABLES

THE EFFECT OF VARIATIONS IN PIGMENT PACKING ON THE PROPERTIES OF EMULSION PAINTS

INTRODUCTION:

In order to predict paint properties from variations in pigmentation it is probably more important to know the particle size distribution than to know the chemical composition of the pigmentation.

The effect of particle size distribution on paint properties is readily demonstrated by use of the pigment packing concept which Mr. D. Bosse has described in "47 Process" Standard Formulating Practice FP-01-A and in "48 Process" Standard Formulating Practice FP-01-B. The advantage of this pigment packing concept over Asbeck and Van Loos' critical pigment volume concentration is that packing indexes can be readily calculated for most combinations of pigments from data which is already available in our formulating practices.

This report will illustrate the effect of systematic changes in the particle size distribution on the packing characteristics of extenders and on various paint properties. The paint properties we investigated were those which we predicted would affect the performance of emulsion house paints e.g. elongation, erosion resistance, sheen, water (scrub) resistance, dirt collection, and shrinkage cracking.

Reference has already been made to some of this work in the following reports: RM-56-23, R-57-17, and R-57-62.

OBJECTIVE:

The main objective of the project under which this work was done was to formulate a durable emulsion house paint.

It was hoped that a better understanding of the role of pigment packing would aid in eliminating some of the deficiencies of these emulsion paints, e.g. insufficient retained elongation, poor coalescence, excessive permeability and excessive dirt collection at low pigment volume concentrations.

SUMMARY AND CONCLUSIONS:

The pigment packing is greatly improved by mixing medium and coarse particle size extenders with fine particle size titanium dioxide. By calculating the packing index for various pigment combinations, the system with the best packing and lowest interstitial volume can be determined.

When higher packing index pigmentations are used in emulsion paints. the following advantages are observed -

(1) Increased elongation, not due to packing index?

(2) Increased water (scrub) resistance,

(3) Decreased sheen,

(4) Improved brushing especially at high solids,

(5) Decreased shrinkage cracking,

(6) Lower raw material cost due to the possibility of increasing the pigment volume concentration and of including more extender.

However, a higher packing index pigmentation usually results in some sacrifice in dirt collection unless the pigment volume concentration is increased.

Calcium carbonate which is a good extender for packing with titanium dioxide causes screen staining and some grades of calcium carbonate increase the erosion.

It is believed that the increase in elongation and some of the other advantages of higher packing index combinations, are due to the higher critical pigment volume concentrations and to the lower specific surface areas of such pigmentations. at equal PVC

ACTION TAKEN:

The emulsion house paint which was selected for trial marketing (Release Letter R-16) was based on the vehicle (Rhoplex AC-33) and the extenders (W-4 and W-88) on which we had the longest durability background in 1956. Since then other theoretically better pigmentations have been exposed but no significant durability advantages have shown up as yet.

Use is being made of the better pigment packing combinations in experimental latices such as poly isobutylene to raise the pigment volume concentration, to decrease dirt collection without sacrificing elongation.

The advantages of the improved pigment packing demonstrated in this work were important in the development of cheaper, higher pigment volume concentration interior paints, e.g. Dripless "Flow Kote" and a cheap polyvinyl acetate interior paint. The low costs of these paints suggested similar work in styrene butadiene paints. As a result "Flow Kote" was made more scrub resistant, flatter and cheaper (Release Letter #1705) by increasing the packing and the pigment volume concentration with calcium carbonate.

what is the cheap PVAC interior paint?

A test method (TM-250) has been issued by W. B. Callahan for the measurement of packing indexes. The Physical Testing Group will soon be equipped to make measurements using this new test method.

ACKNOWLEDGEMENTS:

The packing index calculations used in this report are based on Dave Bosse's formula and nomograph. The experimental work was done expeditiously and carefully by J. J. Gallagher. The writer wishes to acknowledge the helpful suggestions and stimulating discussions provided by D. Bosse, D. L. Herndon, M. Greif, W. J. Hornibrook, W. J. McConeghey and J. J. Nikolich.

MJM:hfm
6/18/58
6/20/58

DISCUSSION:

Polyvinyl acetate house paints based on Elvacet 81-900 emulsion cracked less in Series 13757 when pigmented with extender and TiO_2, than when pigmented with unextended TiO_2. It was hoped to completely eliminate cracking -

1. By still further improving pigmentation (by finding the optimum pigment volume concentration and the optimum extender/TiO_2 ratio, and

2. By improving the vehicle (modifying the polymer to obtain better coalescence, water resistance, low temperature elongation retention).

The latter approach has been emphasized in several research reports (R-57-17, R-57-62).

This report will describe attempts to determine the effect of systematic variations in pigmentation on various paint properties.

The particle size distribution, the shape and the amount of extender can be used to control the number and the size of the interstices or voids which must be filled by polymer in properly formulated paints. If the total void volume is small, the critical pigment volume concentration will be higher. (The critical pigment volume concentration =

$$100 \times \frac{\text{the volume of pigment}}{\text{the volume pigment + the volume of the interstices}}$$

when tightly packed.)

Not clear unless one already knows

Packing index also is inversely proportional to the void volume. As defined by D. Bosse the packing index =

$$\frac{\text{the volume of pigment}}{\text{" " " liquid}}$$

when the pigment or mixture of pigments is dynamically packed. Dynamically packed is defined as "the minimum solid particle packing at which appreciable mechanical interference between pigment particles can be obtained throughout the mixture when subjected to high shear rates (> 1000 sec.$^{-1}$)"

Isn't there a relationship between properties or size of the latex particles and optimum void ratio?

It was reasoned that if the voids, calculated from the packing index, were minimized by the proper choice of extender, a given volume of polymer should be able to fill the voids more completely after the water evaporated. In emulsion paints the discrete polymer particles have to coalesce into these voids and on to the pigment particles.

In the ideal case the polymer should be evenly distributed over the pigment surfaces. It should not be wasted for filling up voids which can be more cheaply filled with pigment particles of the optimum size distribution.

Packing Index and Void Volumes for TiO_2/Magnesium Silicate Pigmentations.

Again one must previously know how to understand where these ratios came from

Since the packing index for "TiPure" R-610 (W-50) is 0.78 ($=\frac{100}{128}$) 100 volumes of W-50 when dynamically packed have 128 volumes of interstices or voids. Similarly since the packing index of magnesium silicate (W-4) is 0.54, ($=\frac{100}{185}$) 100 gallons of this extender require 185 gallons of liquid for dynamic packing. All mixtures of these two pigments can be packed more densely because the fine W-50 can fill the voids between the W-4 particles, and thus "act as a liquid." This packing effect has been calculated. Figure I shows that the mixed system, W-50/W-4, packs tightest in the range where W-50/W-4 = 50/50 to 40/60. A hundred volumes of a 50/50 ratio of W-50/W-4 requires only 75 volumes of liquid to fill the voids, whereas separately W-50 requires 128, and W-4 requires 185 gallons.

The composition range from W-50/W-4 = 50/50 to 40/60 is described as the balanced range. When W-50/W-4 is greater than 50/50 the system is described as an excess finer pigment system; when W-50/W-4 is less than 40/60 it is an excess coarser pigment system. The Formulas used for calculating whether a system is excess finer or excess coarser are given on pages 39 and 40 of Standard Formulating Practice FP-01-B.

Most white emulsion house paints are formulated as excess finer systems because most of the pigment has to be TiO_2 to obtain sufficient hiding. More extender

Would it be desirable to have a colorless extender in the 0.05 to 1.0 micron range? Could we then usefully apply these concepts to high gloss products? Why not?

can be added, however, in colored house paints and these generally showed improved resistance to cracking. More extender can be used in white paints if the pigment volume concentration is increased. Better pigment packing makes higher pigment volume concentration practical, because it increases elongation (see Figure II and paragraphs on Elongation). More extender can also be used in white paints without sacrificing hiding if the solids are increased. Usually higher solids decreases stability and ease of brushing. However, better "pigment packed" systems have improved stability and brushing at higher solids.

The best lead for increasing the extender content was to improve the pigment packing so that higher solids and higher pigment volume concentrations would be possible. Higher pigment volume concentration was also desirable to reduce dirt collection and to reduce cost. An increase in pigment volume concentration from 25 to 35% in a Rhoplex AC-33 (EA/MMA/MAA) emulsion house paint reduces cost by about 12¢ per gallon (when the TiO_2 and the solids are kept constant). With these advantages in mind it was decided to study the effect of pigment packing in Rhoplex AC-33 and Celanese CL-202 (VAc/DBM) emulsion paints. At the time these latexes were the best candidates for emulsion house paints.

Packing Index for TiO_2/Ca CO_3 Pigmentations.

Calculations based on the packing indexes and the effective diameters listed in FP-01-B indicated that the packing index could be varied over quite a wide range if various mixtures were taken of a good packing coarse extender, e.g., W-90, a good packing medium extender, e.g., W-142, and a fine titanium dioxide, e.g., W-50. The "constants" for these pigments have changed somewhat probably due to batch-to-batch variations, etc. The following table lists the constants recorded in the 2/18/55 and the 10/18/57 editions of Standard Formulating Practice FP-01-B.

Code	Description	Packing Index 10/18/57	Packing Index 2/18/55	Effective Diameter 10/18/57	Effective Diameter 2/18/55
W-50	"TiPure R-610	0.78	0.71	0.3	0.4 microns
W-142	Atomite $CaCO_3$	1.33	1.57	4.5	3 microns
W-90	Whiting $CaCO_3$	1.24	1.42	10	10 microns

Do the variation 10/18/57 vs 2/18/55 have meaning? ie should some means be found to control this?

DUP030008894

why select these?

The constants as of 2/18/55 were used to calculate the following packing indexes, void volumes and critical pigment volume concentrations for various mixtures of W-50, W-142, W-90.

Volumes of Pigments, Fine/Medium/Coarse W-50/W-142/W-90			Packing Index	Void Volume	Calculated "Critical Pigment Volume Concentration"
1	0	0	0.71	141%	41%
1	1	0	1.2	83%	55%
1	2	0	1.8	56%	64%
1	1	1	2.0	50%	67%
1	2	2	2.4	42%	71%

These calculated "critical pigment volume concentrations" which are based on packing indexes of the individual pigments, give only a rough approximation of the true critical pigment volume concentration, which as defined originally by Asbeck and Van Loo (Industrial Engineering Chemistry 42, 1470, (1949) was that level of pigmentation at which there are just enough vehicle solids present in the dry film to fill the voids between the pigment particles.

The above system of W-50/W-142/W-90 was selected for this study because it gave a wide range of packing indexes.

Effect of Particle Size Distribution on Various Paint Properties.

As predicted, various paint properties improved as the packing index was increased.

A. Ease of Brushing:

The pigmentations with the highest packing indexes gave paints with the best application properties. The differences were most noticeable at high solids and at the highest pigment volume concentrations. With a straight TiO_2 pigmentation, the brushing was very poor. With increasing amounts of "good packing" extender the slip under the brush improved considerably.

B. Shrinkage Cracking:

Emulsion paints often show mud cracking on drying or on exposure if formulated with too hard a polymer, with too little plasticizer, with too little coalescing agent, or if allowed to dry at too low temperatures. A convenient laboratory test is to allow the emulsion paint to dry over a soft, tacky oil paint. A good formulation will not crack during drying.

The W-50/W-142/W-90 paints based Rhoplex AC-33 and Celanese CL-202 at 30, 40 and 50% pigment volume concentration showed progressively less cracking with increase in the calculated packing index. The following table shows that this cracking is worse at high pigment volume concentrations but can be eliminated even at 40 or 50% pigment volume concentration by improving the packing with medium and coarse grades of calcium carbonate.

SHRINKAGE CRACKING RATINGS
(ON USUAL 0-10 SCALE)

SHOWING THAT CRACKING IS REDUCED BY INCREASING THE PACKING INDEX

W-50/W-142/W-90 Fine/Medium/ Coarse	Pigment Volume Concentration			Packing Index
	50%	40%	30%	
1/0/0	2	4	10	0.71 (measured)
1/1/0	4	8	10	1.2 (calculated)
1/2/0	5	9	10	1.8 "
1/1/1	7	9	10	2.0 "
1/2/2	10	10	10	2.4 "

I cannot reconcile these with photograph.

Photograph I shows that in the Rhoplex AC-33 paints the cracking was reduced but not eliminated by increasing the packing index. After these photographs were taken the writer showed that the cracking could be completely eliminated from low P.V.C. Rhoplex AC-33 paints if casein (2% by weight on the paint) was added. The reason for this decreased shrinkage cracking in the presence of casein is not fully understood. It may be due to the improved pigment wetting or to the improved flow imparted by the casein.

See note page 8

C. Scrub Resistance:

Rhoplex AC-33 and Celanese CL-202 paints had such good scrub resistance at PVC's of 30-40% that it was necessary to go 50-60% PVC before sufficient failures were obtained to show differences due to pigmentation.

The following table shows that the Celanese CL-202 paints at 50% pigment volume concentration showed less failure (when scrubbed with 1% Ivory Flakes for 8,000 strokes after drying overnight) in the pigmentations with the highest packing index.

EFFECT OF INCREASING AMOUNTS OF MEDIUM AND LARGE PARTICLE SIZE CALCIUM CARBONATES ON SCRUB RESISTANCE OF POLYVINYL ACETATE COPOLYMER EMULSION PAINTS (50% PVC)

W-50/W-142/W-90 Fine/Medium/ Coarse	Appearance After 8000 Scrubs	Packing Index
1/0/0	Considerable erosion	0.7
1/1/0	Slight "	1.2
1/2/0	Considerable "	1.8
1/1/1	No erosion	2.0
1/2/2	" "	2.4

The excellent scrub resistance and low sheen of these high pigment volume concentration paints, pigmented with good packing extenders, has been of practical importance in the development of Dripless "Flow Kote" (see R-57-19, The Development of a Gelled Thixotropic Interior Flat Wall Emulsion Paint by R. M. Kirkpatrick), cheaper modifications of "Flow Kote" (Release Letter RL-1705 High Pigment Volume "Tufcote"), and cheap polyvinyl acetate interior paints (Marshall Laboratory Sales Development Memo Report SM-57-11). Competitive Products Report R-41 5/17/57 by H. R. Heikel shows the good balance of properties possessed by these cheaper higher P.V.C. paints.

D. Sheen Reduction:

Low sheen is desirable in both interior and exterior emulsion paints. Although the sheen did decrease with increasing packing index, this was probably coincidental. The low sheen is probably due to the rougher texture of the higher packing index paints which contain more coarser extenders.

Yes see #3 page 2

The following table shows that -

1. Rhoplex AC-33 paints have lower sheen than Celanese CL-202.

2. Increasing the pigment volume concentration decreases the sheen.

Any idea why? latex particle size?

3. Increasing the coarseness of the pigmentation with more extender decreases the sheen.

EFFECT OF MEDIUM AND COARSE PARTICLE SIZE CALCIUM CARBONATE AT VARIOUS PVC'S ON THE 85° SHEEN

Rhoplex AC-33 Paints

W-50	W-142	W-90	P.V.C. 50	40	30
1	0	0	13	37	31
1	1	0	13	9	8
1	2	0	9	10	14
1	1	1	2	3	4
1	2	2	1	2	4

Celanese CL-202 Paints

W-50	W-142	W-90	P.V.C. 50	40	30
1	0	0	50	47	51
1	1	0	11	23	47
1	2	0	7	18	41
1	1	1	3	10	27
1	2	2	2	7	20

3. Elongation:

In emulsion house paints the main deficiency was and probably still is, insufficient elongation to withstand the swelling and contraction of wood or old paint substrates. The following table shows that as the packing index of the pigmentation was increased the elongation increased.

EFFECT OF MEDIUM AND COARSE PARTICLE SIZE CALCIUM CARBONATES ON THE 77°F ELONGATION** OF EMULSION PAINTS AT 40% P.V.C.

Pigmentation W-50/W-142/W-90 Fine/Medium/Coarse			Elongation* Rhoplex AC-33	Elongation* Celanese CL-202	Packing Index
1	0	0	9%	27%	0.7
1	1	0	35%	62%	1.2
1	2	0	138%	149%	1.8
1	1	1	141%	107%	2.0
1	2	2	245%	205%	2.4

*95% confidence limit = ± 44%
**Rate of elongation on Instron = 20%/minute.

An analysis of variance of the above data showed that the TiO_2/calcium carbonate ratio was significant with a 99% probability in controlling the elongation (page 151, Notebook 6249). Although the triplicate measurements of elongation were sufficient to show the significance at 99% probability level of the TiO_2/extender ratio, they did not show a significant difference between the elongation of the Rhoplex AC-33 and the Celanese CL-202 paints. The graph on Figure 2 illustrates the striking effect of these specially selected pigmentations and insignificant effect of the polymer on the % elongation of these paint films.

The same elongation data which were plotted in Figure II to show the effect of packing index have been plotted in Figure III to show the effect of the surface area of the pigment. It is apparent that the increase in elongation is roughly proportional to the decrease in the pigment area.

The following table illustrates how replacing TiO_2 with medium and coarse extenders, decreases the surface area of the pigments, and increases the average thickness of the polymer around the pigment.

EFFECT OF MEDIUM AND COARSE EXTENDERS
ON THE SURFACE AREA OF THE PIGMENTATION
AND ON THE THICKNESS OF THE POLYMER ON THE PIGMENT

Pigmentation W-50/W-4/W-90 Fine/Medium/Coarse			Calculated Surface Area of 40 CCS Pigment	Calculated Thickness of Polymer When 60 CCS Are Spread Over 40 CCS of Pigment (Cf. 40% P.V.C.)
1	0	0	2.2×10^7 cm^2	270 Å
1	1	0	1.1 " " "	530
1	2	0	.79" " "	760
1	1	1	.77" " "	780
1	2	2	.50" " "	1200

The surface areas of the pigmentations were calculated from the specific surface diameters obtained from the pigment suppliers or from the Raw Material Index, National Paint, Varnish & Lacquer Assoc. March 1956. A less accurate estimate could be made from the effective diameters listed in Formulating Practice FP-01-B or from data on the particle size distribution of extender pigments given in a letter from G. C. Fox to J. P. McAndrews 2/3/58.

A possible explanation for the increased elongation which accompanies a decrease in the surface area of the pigment is as follows. In a 40% pigment volume concentration paint, we have 40 volumes of pigment bound with 60 volumes of polymer. If these 40 volumes of pigment are all fine particle size W-50, the surface area will be four times greater than 40 volumes of W-50/W-142/W-90 (= 1/2/2).

The greater the area of pigment the thinner the polymer must be spread. The thinner polymer layers will be difficult to attain because of polymer cohesion and limited coalescence. The thinner layers will also be less easily distorted by stress because of adsorptive forces. Also the greater the area of the pigment the greater will be the number of flaws between pigment and polymer. These flaws undoubtedly contribute to low elongation and cracking on exposure.

It seems reasonable to assume that polymer adsorbed on the surface of a pigment would not readily be distorted by applied stress. Such a pigment system would show low elongation. If the thickness of the polymer on the pigment were increased the elongation should be higher. This is one of the reasons for the increase in elongation which accompanies the decrease in PVC for all emulsion paints in the range of 20-60% PVC. It also may be one of the reasons for the increased elongation which occurs when TiO_2 is replaced by larger particle size extenders. When extenders replace TiO_2 the specific surface area of the mixed pigment is decreased. A given volume of polymer can therefore form a thicker film round each pigment particle and the resulting paint film can then be distorted further.

For improved durabibility we need high elongation not at 77°F, but at low temperatures. At 30°F, Rhoplex AC-33 and Celanese CL-202 paints lose so much of the elongation that the effect of increasing the amount of extender is not as striking as at 77°F.

EFFECT OF MEDIUM AND COARSE PARTICLE SIZE CALCIUM CARBONATES ON THE 30°F ELONGATION** OF EMULSION PAINTS AT 40% PVC

Pigmentation W-50/W-142/W-90			% Elongation* Rhoplex AC-33	% Elongation* Celanese CL-202
1	0	0	0.9	0.5
1	1	0	2.2	1.0
1	2	0	3.5	1.0
1	1	1	2.4	0.9
1	2	2	3.0	1.0

Little if any trend.

*95% Confidence Limit = ± 0.5%.

**Rate of Elongation on Instron = 2%/minute.

Most thermoplastic polymers which are sufficiently non-tacky for house paints, have such low elongations at 30°F that the differences between paints with different pigmentations are often obscured by experimental errors. The data in the following table illustrate the effect of extender on the 30°F elongation of Rhoplex AC-33 paints. The data do not correlate particularly well with the packing indexes of the pigments.

% ELONGATION AT 30°F OF RHOPLEX AC-33 PAINTS PIGMENTED WITH VARIOUS EXTENDERS (PAINT FILMS AGED 10 MONTHS D. 45 SOUTH)

why include?

Pigment Volume Concentration	Mica Talc	Talc	Crystalline Silica	Calcium Carbonate	Wollastonite
25%	3.2	5.0	4.3	7.0	4.3
35%	2.0	2.9	2.5	2.8	2.0

Controls

#40 (301-918)	1.8
#42 (301-888)	2.5
T & S White (87-894)	4.9

Confidence limit for 95% probability = ± 0.7
Least significant difference = 1.0

The "good packing" calcium carbonate (W-90) consistently gives a higher elongation, as shown in the following table, when it replaces the poorer packing W-4/W-88 (magnesium silicate/mica) combination which is used in #44 Acrylic Emulsion House Paint.

Not strictly true

% ELONGATION 30°F OF VARIOUS POLYMERS PIGMENTED WITH TiO_2/CALCIUM CARBONATE

Polymer	W-4/W-88	W-90	Exposure
Rhoplex AC-33	1.9	2.1	12 months in S-15783
Polyvinylpropionate	2.9	1.3	" " " S-15764
Polyvinylpropionate/ divinyladipate	1.7	7.2	" " " "
Firestone's Graft Acrylic	1.4	10.7	6 " " S-15579
Vinylidene Chloride/ octyl acrylate	Data not available	6.3	12 " " S-15824

95% Confidence Limit for 30°F Elongation = ± 0.7%.

Since the paints in the above tables were exposed, a higher packing index pigmentation-W-93/W-16/W-34/W-1004 (titanium dioxide ZL-597/"Ti-Pure" FF/barytes/"Gamaco" calcium carbonate = 13/3/7/7) has been tested in Rhoplex AC-33 and found to give much higher 30°F elongations than the pigmentation at present being used in #44 Acrylic Emulsion House Paint.

INCREASED ELONGATION AT 30°F RESULTING FROM W-93/W-16/W-34/W-1004 PIGMENTATION

Pigmentation	Initial Elongation	Elongation After 7 Months D. 45°
W-93/W-16/W-34/W-1004	30	6.2
W-50/W-16/W-4/W-88	2.1	1.5

This pigmentation is also being tested in polyisobutylene emulsion house paints. This vehicle is especially suitable for this approach because it requires very high pigment volume concentrations to decrease the tack. The higher the PVC the more important does the pigment packing become, and the easier it is to formulate balanced instead of excess finer paints.

F. Permeability to Water:

Another requirement in emulsion house paints for improved resistance to cracking is decreased permeability to water. The lowest permeability of any emulsion paint measured by the writer was shown by a Lytron 680 emulsion paint pigmented with fine TiO_2/medium $CaCO_3$/coarse $CaCO_3$. The impermeability may be due to the dense packing of the W-50/W-142/W-90 and the excellent coalescence of Lytron 680. The following table shows that this paint (Lytron 680 with W-50/W-16/W-142/W-90 at 35% PVC) has such low permeability to water that it approaches that of #42 Outside White, the control solution paint.

LOW PERMEABILITY OF LYTRON 680 PAINT PIGMENTED WITH W-50/W-142/W-90

Pigmentation	Water Evaporated from Payne Cup
W-50/W-142/W-90	0.14 grams/day/mil
W-50/W-4/W-88	0.52 " " "
Control Solution Paint - #42 Outside White	0.11 " " "

Do we want this low a permeability in house paint? May be important in automotive primer etc.

why is this 10?

G. Erosion:

Replacing the chalk resistant "Ti-Pure R-610 (W-50) with medium (W-142) and coarse (W-90) calcium carbonates increased the erosion rate of both Celanese CL-202 and Rhoplex AC-33 paints at 30, 40 and 50% pigment volume concentrations. The percentages of the usual 2.5 mil films which eroded in 18 months Delaware South Vertical are shown in the following tables.

EFFECT OF MEDIUM AND COARSE PARTICLE SIZE CALCIUM CARBONATES ON THE "% EROSION" OF EMULSION HOUSE PAINTS

W-50/W-142/W-90			Rhoplex AC-33 Paints PVC 50	40	30	W-50/W-142/W-90			Celanese CL-202 Paints PVC 50	40	30
1	0	0	2.7*	0.6	0.8	1	0	0	1.2*	1.1	1.7
1	1	0	5.6	4.0	3.4	1	1	0	3.2	2.7	2.2
1	2	0	6.6	5.0	4.4	1	2	0	3.9	3.0	2.5
1	1	1	7.2	4.3	3.9	1	1	1	4.1	3.3	2.9
1	2	2	7.2	5.7	4.4	1	2	2	5.1	7.8	4.2

Controls

#40 Outside White	13.1*
#42 " "	9.9

*% erosion of a 2.5 mil film in 18 months Delaware South Vertical.

H. Dirt Collection:

At constant PVC, Rhoplex AC-33 and Celanese CL-202 paints became progressively dirtier on exposure as the ratio of TiO_2 to calcium carbonate was decreased. This may be due to the lower critical PVC or to the coarser texture of these paints.

I. Screen Staining:

Calcium carbonate increased the copper and iron screen staining of these emulsion paints but the staining was not as bad as calcium carbonate in linseed oil paints.

MJM:hfm
6/19/58
6/24/58

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Extender Pigments. Particle Size Distribution Data. Letter of G. C. Fox to J. P. McAndrews 2/3/58.

FIGURE I

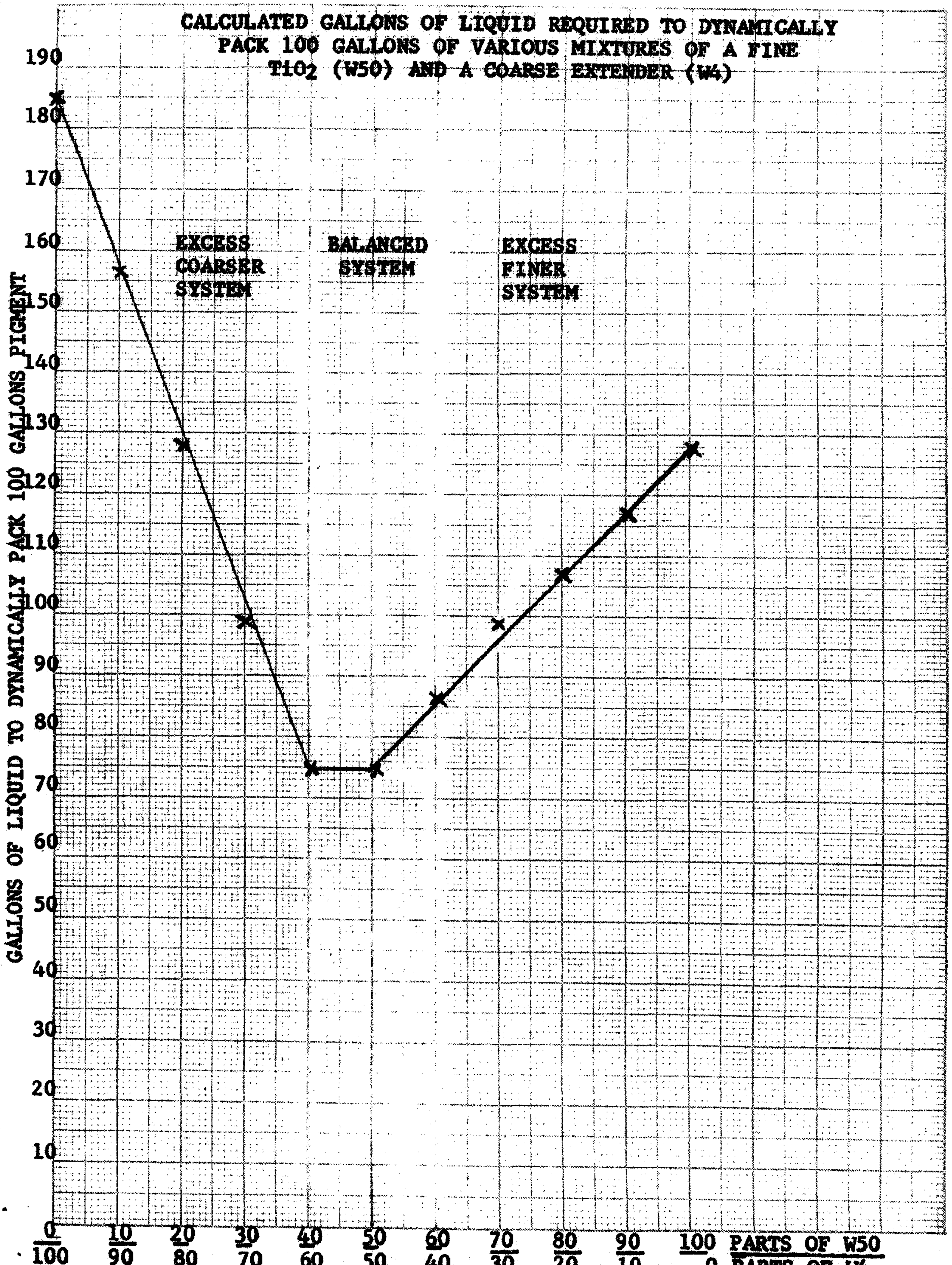

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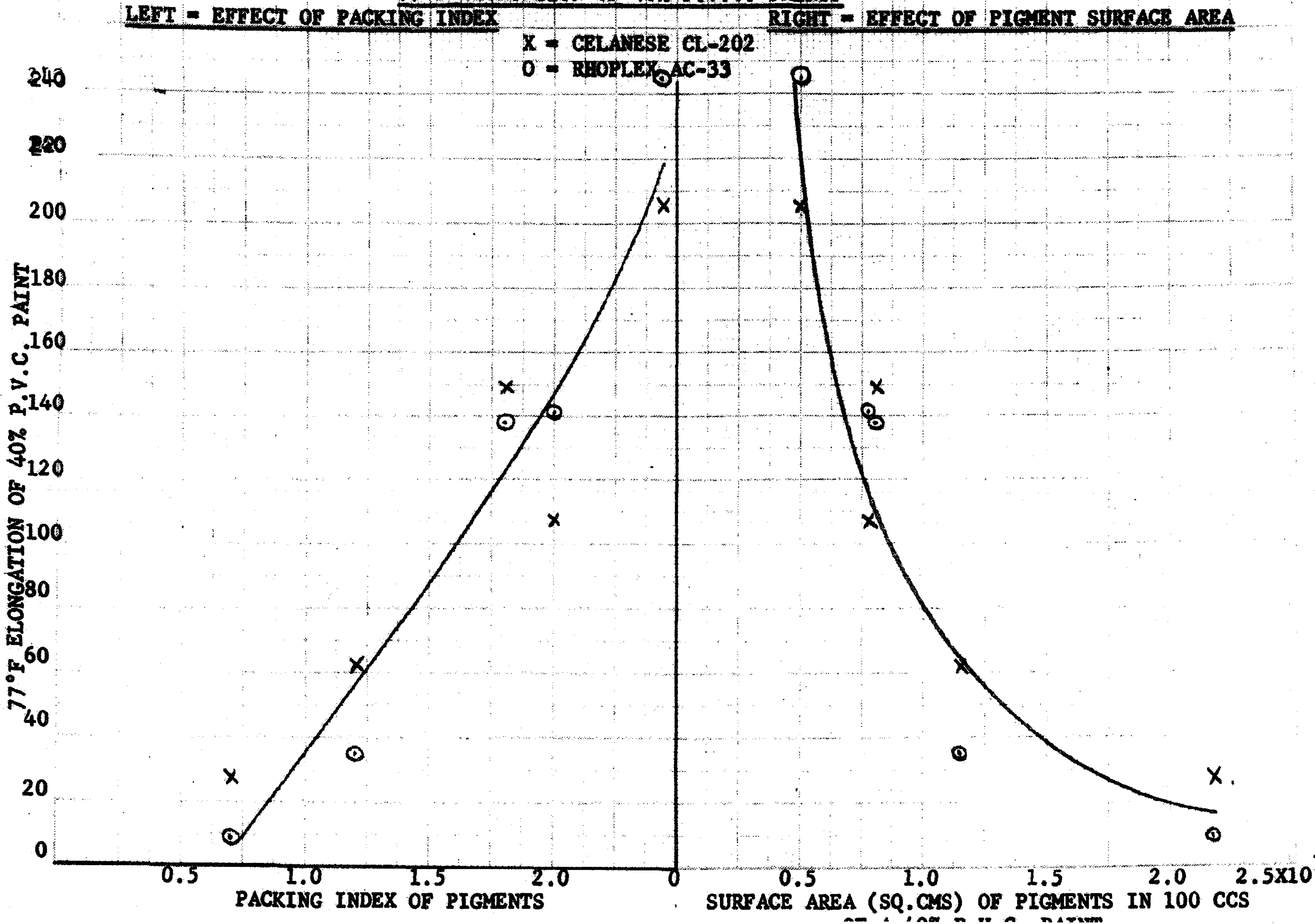
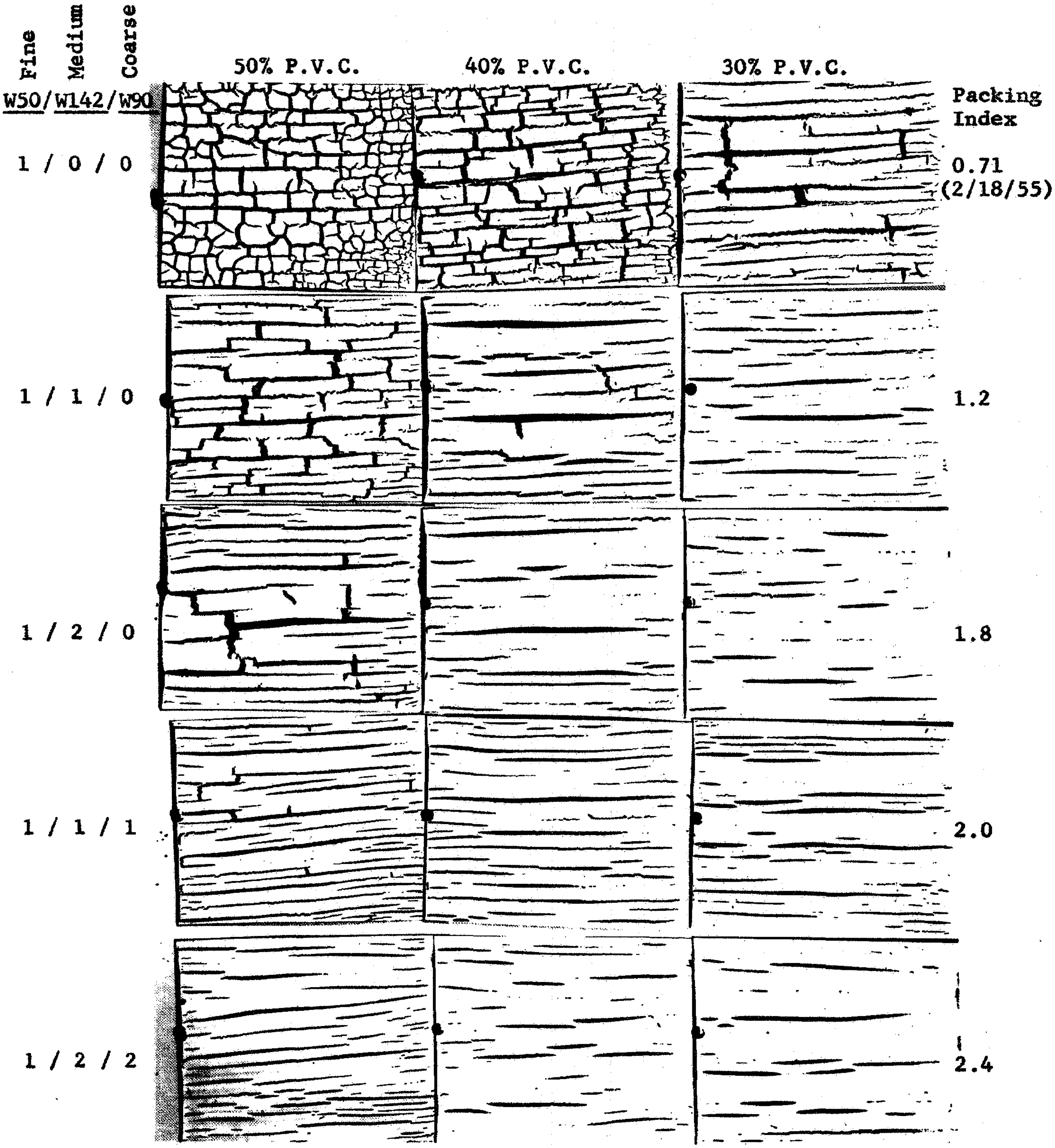
FIGURE II

FIGURE III

77°F ELONGATION OF 40% P.V.C. PAINTS



DUP030008908



EFFECT OF PACKING INDEX AND PARTICLE SIZE DISTRIBUTION ON SHRINKAGE CRACKING OF 30, 40 & 50% P.V.C. RHOPLEX AC-33 PAINTS

PHOTOGRAPH I