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EVALUATION OF  
ARCHITECTURAL COATINGS II

PART A

INTERIOR WALL ENAMELS

SEALING QUALITIES OF  
INTERIOR WALL PRIMERS

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Contract No. A0-075-31

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Prepared For The

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## EXECUTIVE SUMMARY

### A. Interior Wall Enamels

An important source of air pollution is the evaporation of solvent during the application of interior wall enamels. Consequently, the California Air Resources Board (CARB) has reduced the allowable level of volatile organic compounds (VOC) to a level of 350 grams per liter of paint, less any water. In a continuing effort to further improve air quality CARB has scheduled a reduction of the VOC level to 250 grams per liter of paint, less water. However, before doing so, CARB desired to determine the availability and performance of coatings that comply with the new standard.

Consequently, 13 water based enamels, four high solids (VOC<350 gms/liter) enamels and ten conventional (VOC>350 gms/liter) enamels were obtained, either by purchase or from paint manufacturers, and were submitted to the D/L Laboratories for evaluation. In addition, three samples of water based enamels were obtained from raw material suppliers in order to evaluate the latest technology available to the industry.

Among the water based enamels, nine have VOC levels below 250 grams per liter, and seven, including the raw material supplier samples, have VOC levels between 250 and 350 grams per liter. Among the high solids enamels, one has a VOC level below 250 grams per liter and three have VOC levels between 250 and 350 grams per liter.

Prices of the proprietary water based enamels vary from \$10 to \$29 per gallon. The high solids enamels cost between \$14 and \$27 per gallon including \$1 per gallon for thinning and cleaning solvent. The conventional enamels cost between \$17 and \$27 including the \$1 per gallon for thinning and cleaning enamels.

Gloss levels of the water based enamels vary from 21 to 84 for the proprietary coatings and from 76 to 90 for those received from raw material suppliers. The high solids enamels have gloss levels from 61 to 80 and the conventional enamel gloss levels vary from 30 to 90.

Both the water based and high solids enamels, as a group, are not competitive with the conventional enamels overall. However, when the best three water-based, two high solids and three conventional enamels are compared, the comparative ratings of low VOC enamels are substantially improved.

Two proprietary water based enamels can be considered to be acceptable products, exhibiting above average performance and no serious deficiencies. Both have VOC levels just above 250 grams per liter and are above average in cost per gallon. Their gloss levels vary from high to just below average.

One high solids enamel can be considered to be an acceptable product exhibiting above average performance and no serious deficiencies. Its VOC level is just under 350 grams per liter, and its cost is the lowest of all the solvent thinned paints tested. Its gloss level is average for that group. It is interesting to note that the enamel which exhibited the best overall performance has a solvent content of 363 grams per liter.

The samples received from the raw material suppliers are above average in performance among the water based coatings tested, but each has a serious deficiency which would limit its use.

When specific properties are considered, the best water based enamel for a given property is at least equal to the best conventional enamel for that property, with one exception - print resistance - a relatively unimportant property. This is not so with the best high solids enamel, which though considered an acceptable product overall is not equal to the best conventional enamel in a number of specific properties.

The importance of the properties tested can vary with the end use. Therefore deficiencies can be overlooked for specific and limited applications, e.g., scrub resistance in a bathroom, block resistance on woodwork, etc. If this is taken into consideration then:

- 3 water based and 2 high solids coatings are acceptable for use in kitchens
- 5 water based and only one high solids coating are acceptable for use in bathrooms
- 3 water based and the same high solids coating are acceptable for use on woodwork
- 2 water based and two high solids coatings are acceptable for use on shelving

However, it must be realized that enamels are generally used for more than one of the above areas, often for all four.

Inasmuch as both water based and high solids enamels, as a group, are less resistant, hence more prone to damage, e.g., by staining, scrubbing, loss of adhesion, etc., than conventional enamels, it is possible that more frequent repainting may be required.

B. Interior Wall Primers

The four water based primers and two conventional (solvent-thinned) primers tested under Contract No. A8-095-31 were compared for their ability to seal both water-soluble and grease-type stains.

The results demonstrated that none of the five water based primers tested will seal water-soluble stains as effectively as the conventional primers. On the other hand, all of them will seal oil and grease-type stains more effectively than the conventional primers.

ACKNOWLEDGEMENTS

The key personnel responsible for this project were:

Sidney B. Levinson	-	President
Saul Spindel	-	Vice President & Technical Director
Jerry H. Willner	-	Senior Chemist
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This report is submitted in partial fulfillment of CARB Contract No. A0-075-31 by the David Litter Laboratories d/b/a D/L Laboratories under the sponsorship of the California Air Resources Board.

DISCLAIMER

The statements and conclusions in this report are those of the contractor and not necessarily those of the California Air Resources Board. The mention of commercial products, their source or use in connection with material reported herein is not to be construed as either an actual or implied endorsement of these products.

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I SUMMARY AND CONCLUSIONS

A. Interior Wall Enamels

1. Overall

- a. The water based enamels, as a group, tend to exhibit the following significant differences vs conventional enamels:

<u>Superior</u>	<u>Inferior</u>
Package stability	Leveling
Ease of application	Stain removal
Drying speed	Adhesion - wet or dry
Gloss retention	Scrub resistance
Color retention	Block resistance
Wet edge	Print resistance
	Water spotting resistance

They also produce higher coverage rates on primed surfaces because of their ease of application.

- b. Among the water based enamels submitted by raw material suppliers, two, Nos. 32 and 33, are above average in performance except for a major defect which would limit their use. No. 32 is deficient in block resistance and therefore should not be used on woodwork and shelving. No. 33 is deficient in scrub resistance and thus would be limited to use in bathrooms (See Table 9). Both have VOC levels just above the 250 grams per liter desired.
- c. The water based samples submitted by the raw material suppliers, as a group, exhibit one major advantage vs the proprietary water based enamels, as a group, namely, good adhesion, both wet and dry.
- d. The high solids enamels, as a group, tend to exhibit the following significant differences vs the conventional enamels:

<u>Superior</u>	<u>Inferior</u>
Stability	Slower recoat time
Wet edge	Slower drying speed
Stain removal	Excessive film defects
	Block resistance
	Print resistance
	Color retention

2. Best Enamels

- a. The best three water based enamels, Nos. 5, 17 and 19, are much closer to the conventional paints in overall performance. Among the best water based enamels tested, two, Nos. 17 and 19, can be considered to be acceptable coatings. Both are above average in performance and neither exhibits any serious deficiencies. Both enamels have VOC levels close to 260 grams per liter of paint, less water. However, as a group, the three water based enamels are still inferior to the best conventional enamels in recoat time, opacity, stain removal, scrub resistance, block resistance and water spotting resistance, but superior in drying speed and gloss retention.
- b. The best two high solids enamels, Nos. 27 and 30, are closer to the conventional paints overall with especially good stain removal. Of the high solids enamels tested, one, No. 30, can be considered to be acceptable. It is above average in performance and exhibits no serious deficiencies. It has a VOC level just below 350 grams per liter. However, as a group, the two high solids enamels are still inferior to the best conventional enamels in recoat time, drying speed, leveling, block resistance, print resistance and color retention.

3. Specific Properties

- a. It is evident that water based enamels can at least equal conventional enamels in essentially all of the individual properties tested.
- b. The best water based enamel for that property is superior to the best conventional enamel in the following properties:

Storage stability  
Drying speed  
Opacity

All other properties are at least equal - best vs best - with only one minor exception - print resistance - which is of relatively minor importance.

- c. The best high solids enamel for that property is equal to the best conventional enamel in all properties tested except the following:

Slow recoat time  
Leveling  
Opacity  
Tintability  
Block resistance  
Print resistance  
Color retention

4. Effect of VOC, Gloss and Price

- a. The best water based enamels have VOC levels just above 250 grams per liter. On the other hand, the best high solids enamels have VOC levels just below 350 grams per liter.
- b. Gloss level appears to have no significant effect on performance although overall performance tends to be slightly better at higher gloss levels.
- c. Price per gallon of the best water based enamels tends to be average or above average for the group. On the other hand, the price per gallon of the best high solids enamels is below average for the group. In fact, the best high solids enamel has the lowest price of all of the solvent thinned paints tested.

5. Frequency of Repainting

Inasmuch as the low VOC enamels tested, as a group, exhibit less resistance to damage or disfigurement than conventional enamels, i.e., stain removal, scrub resistance, adhesion, block resistance, color retention, etc., depending on the type, more frequent repainting may be required. However, the frequency cannot be determined by laboratory testing.

B. Interior Wall Primers

It is evident from this evaluation that water based primers will not readily seal water soluble stains. On the other hand, they are very effective on grease type stains.

II RECOMMENDATIONS

A. Interior Wall Enamels

1. It is evident, from the results of this evaluation, that low VOC level paints, especially water based, can be developed which can readily compete with conventional paints. However further work is required to overcome their present deficiencies as a group, primarily stain removal, adhesion and resistance to scrubbing, blocking, print and water spotting. Furthermore, VOC levels of all of the best low VOC coatings tested were above 250 grams per liter.

Therefore, CARB should approve VOC levels above 250 grams and preferably close to 350 grams per liter for some period of time to enable paint manufacturers to develop improved products.

2. All wall coatings tend to improve in performance with age. Furthermore, many properties judged to be inferior, based on short term laboratory tests, may indeed be satisfactory after longer periods of ageing, as would be the case in actual use.

Therefore, it would be advisable to recheck the following properties after the paint films have been allowed to age for one or two months:

- Stain removal
- Adhesion - wet and dry
- Scrub resistance
- Block resistance
- Print resistance
- Water spotting resistance

B. Interior Wall Primers

Conventional wall primers should be allowed for use on walls which have been stained by water soluble stains until improved low VOC primers are available. High solids primers, if available, should be satisfactory for this purpose.

Low VOC water based primers should be capable of normal use otherwise.

### III INTRODUCTION

Local air pollution control agencies in California have recently come under pressure to delay full implementation of their regulations to control the volatile organic solvent content of architectural coatings. These regulations, which are based on the California Air Resources Board model rule, restricts the organic solvent content of architectural coatings, in general, to 250 grams per liter of coating as applied, excluding water. Exterior house coatings were subject to this limitation on the effective date of the regulation, while interior wall coatings were to be subject to the 250 gram limit after a one year interim limit of 350 grams. All other categories of architectural coatings were exempted until acceptable complying coatings are developed. An evaluation of exempt coatings is the subject of part B of this report.

The interim limit for interior wall coatings expired on September 2, 1980 in most areas of the State. However, the South Coast Air Quality Management District granted an extension of the interim limit to September 4, 1981, pending a technical review by both SCAQMD and ARB. This action was prompted by industry claims that interior enamels with solvent contents below 250 grams per liter are not competitive with enamels containing higher amounts of solvent due to either poor adhesion, gloss, scrub resistance or other deficiencies in performance. Additionally, complying interior wall primers are claimed to be inferior to conventional solvent-thinned primers in sealing water soluble stains.

D/L Laboratories was retained by CARB to determine whether or not performance of the low VOC paints would be inferior, as claimed, by testing samples of both the low VOC paints and competitive conventional products. CARB submitted recommendations for the properties to be evaluated both from the manufacturers and from their own experience. These were reviewed and modified by the D/L Laboratories to achieve a comprehensive series of tests which would answer the questions raised by the manufacturers and cover all major properties which might be affected by reducing the VOC level.

### IV OBJECTIVES

#### A. Interior Wall Enamels

The purpose of this evaluation was to determine whether or not CARB conforming products containing less than 250 gm/liter of VOC (less water) are available which are competitive with equivalent conventional solvent-thinned enamels.

#### B. Interior Wall Primers

The purpose of this limited study was to determine the relative ability of water based wall primers to seal (prevent bleed-through) of water soluble stains are compared with conventional solvent-thinned primers.

V PROCEDURE

A. Interior Wall Enamels

The following tests were made on all of the samples submitted:

1. Weight per gallon
2. Total solids
3. Viscosity - Initial, 2 wks at 125°F, 4 wks at 125°F
4. Storage Stability - 2 wks at 125°F, 4 wks at 125°F
  - Liquid separation
  - Skinning
  - Pigment settling
  - Ease of remixing
5. Ease of application - Primed surface, unprimed surface
6. Coverage rate - Primed surface, unprimed surface
7. Wet edge retention - 77°F and 50% R.H., 50°F and high R.H.
8. Recoat time - 77°F and 50% R.H., 50°F and high R.H.
9. Drying time - 77°F and 50% R.H., 50°F and high R.H.
  - Set to touch
  - Tack free
  - Dry hard
  - Dry thru
10. Leveling - Primed surface, unprimed surface
11. Gloss-60° - Drawdown
12. Opacity
  - Drawdown
  - Rolled over grey stripe - Primed surface
  - Unprimed surface
13. Film defects - Primed surface, unprimed surface
14. Tintability
  - Color acceptance (depth of color)
  - Color development (dispersion)
  - Red iron oxide
  - Phthalocyanine green
15. Stain removal - pencil, crayon, grease
16. Adhesion to glossy enamel

R.H. - Relative humidity

18. Scrub resistance
19. Resistance to blocking - front to front, front to back
20. Print resistance
21. Water spotting
22. Gloss retention
23. Color retention

B. Interior Wall Primers

The following tests were made on both the water based and conventional interior wall primers:

Sealing of water soluble stains  
Rusty water  
Coffee  
Tea

Sealing of a grease stain

VI PRODUCTS TESTED

A. Interior Wall Enamels

The interior wall enamels tested are shown in Table 1. They are classified as to type of product and level of gloss. Included are the data submitted by the manufacturer, namely the type of polymer and the selling price per gallon (to the nearest dollar). The actual VOC levels determined are also included.

Note that three products have been omitted from the 33 originally obtained:

- 16 - Experimental product
- 24 - Determined to be an exterior paint
- 28 - Experimental product

Table 1  
Interior Wall Enamels

No.	Type			VOC (g/l)	Gloss (Label)		Polymer	\$/Gal
	W-B	H-S	Conv.		Low	High		
1	X			253	X		Acr	15
2	X			75	X		Acr	15
3			X	364	X		Alk	19*
4		X		304	X		Alk	19*
5	X			310	X		Acr	17
6			X	434		X	Alk	18*
7			X	480	X		Alk	18*
8	X			211	X		PV-Acr	18
9			X	417		X	Alk	22*
10			X	448	X		Alk	20*
11	X			103	X		Acr	16
12	X			217		X	ND	16
13			X	418	X		Alk	27*
14		X		234	X		Alk	27*
15			X	418		X	Alk	23*
17	X			262		X	ND	29
18	X			244	X		ND	29
19	X			258	X		Acr	19
20			X	418	X		Alk	21*
21	X			162	X		ND	13
22			X	447		X	Alk	18*
23	X			152	X		Mod PV	10
25	X			194	X		PV	16
26			X	361	X		Alk	17*
27		X		349	X		Alk	18*
29	X			148	X		Acr	12
30		X		346	X		Alk	14*
31	X			315		X	Acr	**
32	X			254		X	Acr	**
33	X			281		X	Alk	**
	<u>16</u>	<u>4</u>	<u>10</u>					

W-B - Water base  
H-S - High Solids (VOC=<350 g/l)  
Conv. - Conventional (VOC=>350 g/l)  
VOC - Volatile organic compounds  
g/l - Grams per liter, less water  
ND - No data

Acr - Acrylic  
Alk - Alkyd  
PV - Polyvinyl acetate  
Mod - Modified  
\* - Includes \$1/gal for thinning & cleanup solvent  
\*\* - From raw material supplier

NOTE: All enamels are white.

B. Interior Wall Primers

The interior wall primers tested are the same as those tested under contract No. A8-095-31. See report dated September 22, 1980, Class 4C on pg 13C. They are listed in Table 2 below:

Table 2  
Interior Wall Primers

<u>No.</u>	<u>Supplier *</u>	<u>Color</u>	<u>Type</u>	<u>VOC</u>		<u>Price</u>	
				<u>g/l</u>	<u>%</u>	<u>\$/Gal</u>	<u>Date</u>
12	13	All	WB		7.2	9.50	5/79
16	13	are	Conv	-		No data	
19	7	White	WB	78	2.3	RMS	
22	4		WB	143		10.50	8/79
25	22		WB	141		8.00	8/79
45	9		WB	36		8.00	5/80
46	9		Conv	-		9.99	5/80

WB - Water base  
Conv - Conventional  
RMS - Raw material supplier  
VOC - Data from manufacturer  
g/l - Grams per liter

\* See report on Contract No. A8-095-31 dated September 22, 1980.

NOTE: All primers are white

VII TEST RESULTS

Tests were chosen by consultation with CARB technical personnel. The results are shown in the following Appendices:

- I Interior Wall Enamels - Water Based
- II Interior Wall Enamels - High Solids
- III Interior Wall Enamels - Conventional
- IV Interior Wall Primers

See Section IX "Glossary" for a description of the properties tested, Section X "Code and Abbreviations" for an explanation of the terms used and Appendix V "Test Procedures" for a description of the test methods used.

Inasmuch as some tests are subjective, the observations made have been scored using the following ASTM Scoring Scheme:

<u>Score</u>	<u>Performance</u>	or	<u>Effect</u>
10	Perfect		None
9	Excellent		Trace
8	Very good		Very slight
6	Good		Slight
4	Fair		Moderate
2	Poor		Considerable
1	Very poor		Severe
0	No value		Failed

The use of this numerical scheme avoids the necessity for the use of verbal descriptions in the test data tables.

## VIII DISCUSSION OF RESULTS

### A. Interior Wall Enamels

The test results can most effectively be rated, compared and analyzed by assigning the following values to the results obtained or observations made:

- 10 = Decidedly above average for all enamels tested
- 7 = Significantly above average
- 5 = Average
- 3 = Significantly below average
- 0 = Decidedly below average for all enamels tested

These values are shown in the following tables:

#### Table

- 3. Ratings of Water Based Enamels
- 4. Ratings of High Solids Enamels
- 5. Ratings of Conventional Enamels

Note that the following results and observations have only been described since they normally have no direct effect on performance:

Weight per gallon

Total solids

Viscosity

Coverage rate

Gloss

These have been described as follows:

- Very high - Decidedly above average value for all enamels
- High - Significantly above average values
- Low - Significantly below average values
- Very low - Decidedly below average values for all of the enamels tested

Also note that some test results and/or observations have been combined for the sake of space:

Storage Stability - Includes viscosity changes, liquid separation, skinning, settling and ease of re-mixing.

Application Ease - Includes primed and unprimed surfaces.

Coverage Rate - Includes primed and unprimed surfaces.

Wet Edge - Includes ambient and cold, damp conditions.

Recoat Time - Includes ambient and cold, damp conditions.

Drying Speed - Includes tack-free time, dry hard and dry thru, both ambient and under cold, damp conditions.

Note: Wet Edge is more practical than Set-to-touch and has been used instead.

Leveling - Includes primed and unprimed surfaces.

Opacity - Includes opacity on primed surfaces, unprimed surfaces and by drawdown.

Tintability - Combines Color Acceptance and Color Development with both red iron oxide and phthalocyanine green tinting colors.

Stain Removal - Includes pencil, crayon and grease stains.

Block Resistance - Includes blocking front-to-front and back-to-front.

#### 1. VOC Levels

The VOC concentration of each of the water based and high solids coatings was determined with the results shown in Table 1 above.

Table 3

Ratings of Water Based Enamels

	<u>1</u>	<u>2</u>	<u>5</u>	<u>8</u>	<u>11</u>	<u>12</u>	<u>17</u>	<u>18</u>	<u>19</u>	<u>21</u>	<u>23</u>	<u>25</u>	<u>29</u>
Gloss (Label) --->	L	L	L	L	L	H	H	L	L	L	L	L	L
VOC <250 g/l---->		X		X	X	X		X		X	X	X	X
Weight per Gallon							L	L			VH		
Total Solids	VL	L	VL	L		L	L	VL	L			L	
Viscosity		VL		L			VL		H		H		
Storage Stability	10	5	5	5	5	5	5	5	5	5	5	5	7
Application Ease	5	5	5	5	5	5	5	5	5	5	5	5	5
Coverage Rate	H	H	VH									H	
Wet Edge	5	5	5	5	5	5	5	5	5	5	3	5	5
Recoat Time	7	5	5	5	7	5	7	5	7	7	10	5	7
Drying Speed	7	10	7	7	10	7	10	10	10	10	10	7	10
Leveling	5	5	5	5	3	3	7	5	5	5	5	0	3
Gloss	VL				L		H				L		
Opacity	3	5	5	3	5	5	3	0	5	7	10	5	3
Film Defects	5	5	5	0	5	5	5	5	5	5	3	3	5
Tintability	5	7	7	5	7	5	5	7	3	3	5	5	3
Stain Removal	0	5	5	5	5	7	10	5	3	0	3	5	10
Adhesion	0	0	5	0	0	0	5	5	5	3	0	0	5
Scrub Resistance	5	0	3	0	5	7	5	5	3	5	10	0	3
Block Resistance	5	5	10	5	3	3	3	5	5	3	0	0	0
Print Resistance	5	5	7	3	3	3	5	5	5	3	0	3	3
Water Spotting	0	0	0	3	5	5	7	7	5	5	3	3	5
Wet Adhesion	0	3	7	0	7	7	7	7	5	3	0	5	0
Gloss Retention	5	7	7	7	7	10	5	7	7	7	5	7	7
Color Retention	7	7	5	5	7	7	7	7	5	7	5	5	7

L - Low      H - High      V - Very

Table 3 (Cont)

Ratings of Water Based Enamels

	<u>31</u> H	<u>32</u> H	<u>33</u> H
Gloss (Label) ----->			
VOC <250 g/l ----->			
Weight per Gallon	L	L	L
Total Solids	L	L	L
Viscosity		H	
Storage Stability	5	5	3
Application Ease	5	5	3
Coverage Rate	H	H	L
Wet Edge	3	5	5
Recoat Time	7	5	5
Drying Speed	7	10	5
Leveling	5	5	7
Gloss	H	H	VH
Opacity	3	3	5
Film Defects	3	5	5
Tintability	0	5	7
Stain Removal	7	10	10
Adhesion	5	5	5
Scrub Resistance	5	3	0
Block Resistance	0	0	5
Print Resistance	5	3	7
Water Spotting	5	7	7
Wet Adhesion	7	7	7
Gloss Retention	7	5	7
Color Retention	5	7	7

Table 4

Ratings of High Solids Enamels

	<u>4</u> Low	<u>14</u> Low X	<u>27</u> Low	<u>30</u> Low
Weight per Gallon	VH			H
Total Solids	H	VH	H	H
Viscosity			H	
Storage Stability	5	5	5	5
Application Ease	5	0	5	5
Coverage		L		
Wet Edge	5	3	5	5
Recoat Time	5	3	3	5
Drying Speed	3	3	5	3
Leveling	5	5	3	5
Gloss		H	H	H
Opacity	5	5	5	5
Film Defects	3	5	3	5
Tintability	5	5	5	5
Stain Removal	7*	5	7	10
Adhesion	5	5	5	5
Scrub Resistance	0	7	7	5
Block Resistance	5	5	0	5
Print Resistance	7	3	3	5
Water Spotting	5	7	7	7
Wet Adhesion	7	7	7	7
Gloss Retention	3	3	5	5
Color Retention	0	0	3	5

\* Most likely due to poor scrub resistance

Table 5

Ratings of Conventional Enamels

	$\frac{3}{L}$	$\frac{6}{H}$	$\frac{7}{L}$	$\frac{9}{H}$	$\frac{10}{L}$	$\frac{13}{L}$	$\frac{15}{H}$	$\frac{20}{L}$	$\frac{22}{H}$	$\frac{26}{L}$
Gloss ----->										
Weight per Gallon	H			L			VL			H
Total Solids	H									H
Viscosity			L		H	H		H		VH
Storage Stability	5	5	5	3	5	5	0	5	5	0
Application Ease	3	5	5	5	5	0	0	5	5	5
Coverage			VH			VL	VL			
Wet Edge	5	3	0	5	5	5	5	3	3	5
Recoat Time	10	10	3	7	5	5	5	5	3	10
Drying Speed	3	5	5	5	5	3	3	5	5	5
Leveling	5	5	7	7	5	5	5	5	7	7
Gloss	L			VH	L	L	VH		H	
Opacity	3	7	5	5	5	5	5	7	7	5
Film Defects	3	3	5	5	5	5	5	5	5	5
Tintability	7	7	7	3	5	3	7	3	0	7
Stain Removal	5	7	7	10	5	5	7	7	7	5
Adhesion	5	5	5	3	5	5	5	5	5	5
Scrub Resistance	3	3	3	10	3	5	5	5	7	7
Block Resistance	10	10	10	10	10	7	0	5	3	5
Print Resistance	7	5	7	7	10	7	3	5	5	5
Water Spotting	5	7	7	7	7	7	7	7	7	7
Wet Adhesion	7	7	7	7	7	7	7	7	7	7
Gloss Retention	5	3	3	5	5	5	7	5	5	5
Color Retention	5	5	5	5	5	5	3	7	5	5

2. Comparison of Proprietary Enamels

The low VOC coatings, as a group, were generally inferior to the conventional enamels. However a review of Tables 3 to 5 above shows that some products were superior to the others of the same type. These were as follows:

Water Based

- No. 5 - This enamel could be considered to be acceptable. However it was deficient in water spotting which would limit its use to woodwork. Outstanding block resistance.
- No. 17 - The best enamel, overall, with no serious deficiencies. Outstanding drying speed and stain removal.
- No. 19 - A marginal product with no serious deficiencies. Outstanding drying speed.

High Solids

- No. 27 - A marginally acceptable product and superior to most other high solids enamels except for its deficient block resistance which would hinder its use on shelving.
- No. 30 - An acceptable product and definitely superior to the other high solids enamels. Outstanding stain removal.

3. Raw Material Supplier Samples

Three water based enamels (Nos. 31, 32 & 33) were submitted by raw material suppliers.

A review of Table 3 above demonstrates that two, Nos. 32 and 33, were the best of the three. However, No. 32 was deficient in block resistance and No. 33 was deficient in scrub resistance. It is interesting to note that all three had good adhesion - dry and wet.

4. Comparison of Best Enamels

Continuing the above comparison, the results can be analyzed more effectively by comparing the best water based and high solids enamels above with the three best conventional enamels in order to determine their relative superiority, both vs all those tested and vs the best available, regardless of regulations.

The best conventional enamels evaluated were Nos. 6, 9 and 26. The averages of the rated properties overall and for the best enamels are shown in Table 6 and are graphically demonstrated in Graphs 1 and 2.

Table 6

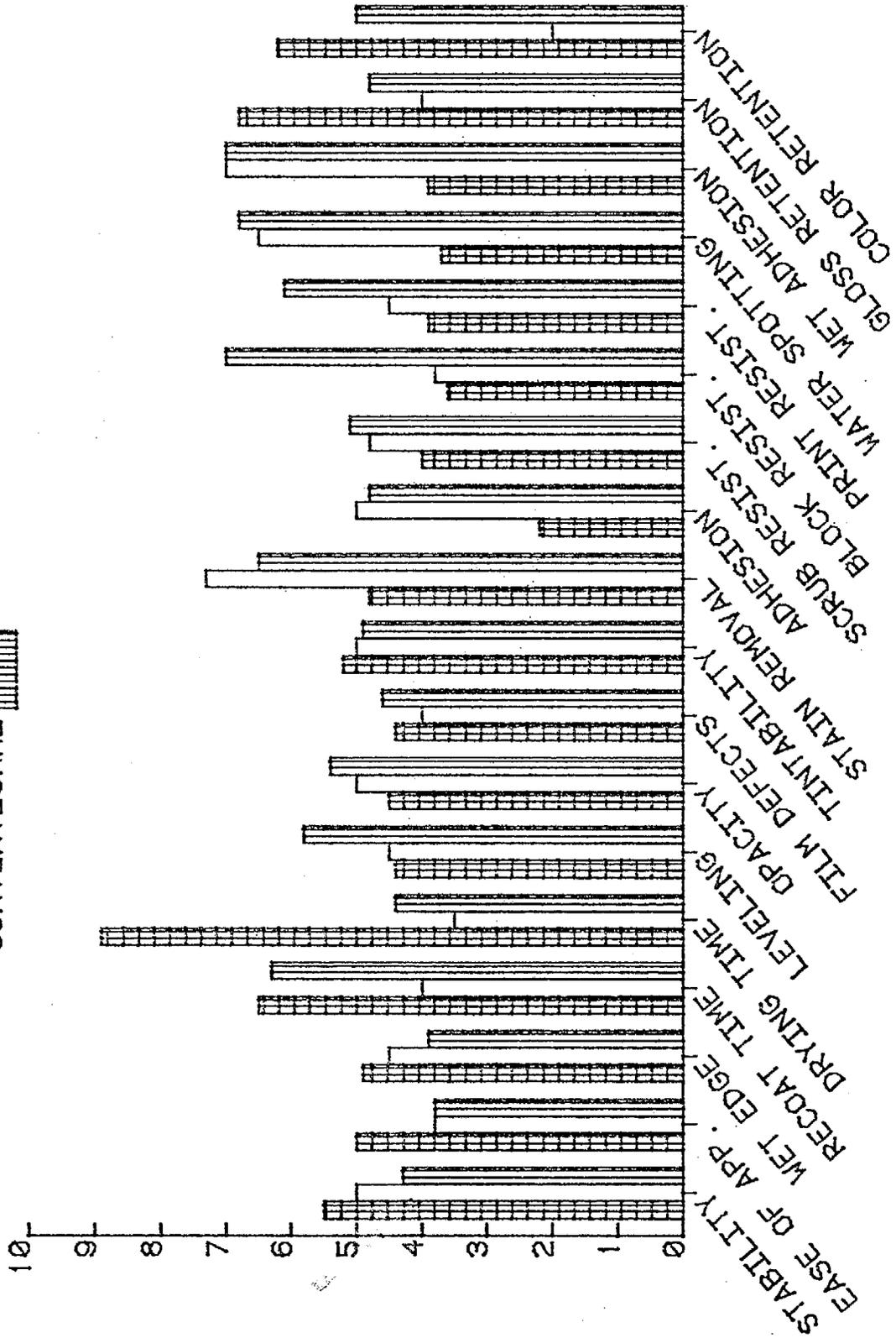
Average Ratings - Interior Wall Enamels

Total Samples	Overall			Best Products		
	WB (13)	HS (4)	Conv (10)	WB (3)	HS (2)	Conv (3)
Storage Stability	5.5	5.0	4.3	5.0	5.0	4.3
Application Ease	5.0	3.8	3.8	5.0	5.0	5.0
Wet Edge	4.9	4.5	3.9	5.0	5.0	4.3
Recoat Time	6.5	4.0	6.3	6.3	4.0	9.0
Drying Speed	8.9	3.5	4.4	9.0	4.0	5.0
Leveling	4.4	4.5	5.8	5.7	4.0	6.3
Opacity	4.5	5.0	5.4	4.3	5.0	5.7
Film Defects	4.4	4.0	4.6	5.0	4.0	4.3
Tintability	5.2	5.0	4.9	5.0	5.0	5.7
Stain Removal	4.8	7.3	6.5	6.0	8.5	7.3
Adhesion	2.2	5.0	4.8	5.0	5.0	4.3
Scrub Resistance	4.0	4.8	5.1	3.7	6.0	6.7
Block Resistance	3.6	3.8	7.0	6.0	2.5	8.3
Print Resistance	3.9	4.5	6.1	5.7	4.0	6.1
Water Spotting	3.7	6.5	6.8	4.0	7.0	7.0
Wet Adhesion	3.9	7.0	7.0	6.3	7.0	7.0
Gloss Retention	6.8	4.0	4.8	6.3	5.0	4.3
Color Retention	6.2	2.0	5.0	5.7	4.0	5.0
Best Products				5	27	6
				17	30	9
				19		26

WB - Water Based  
 HS - High Solids  
 Conv - Conventional

Graph 1

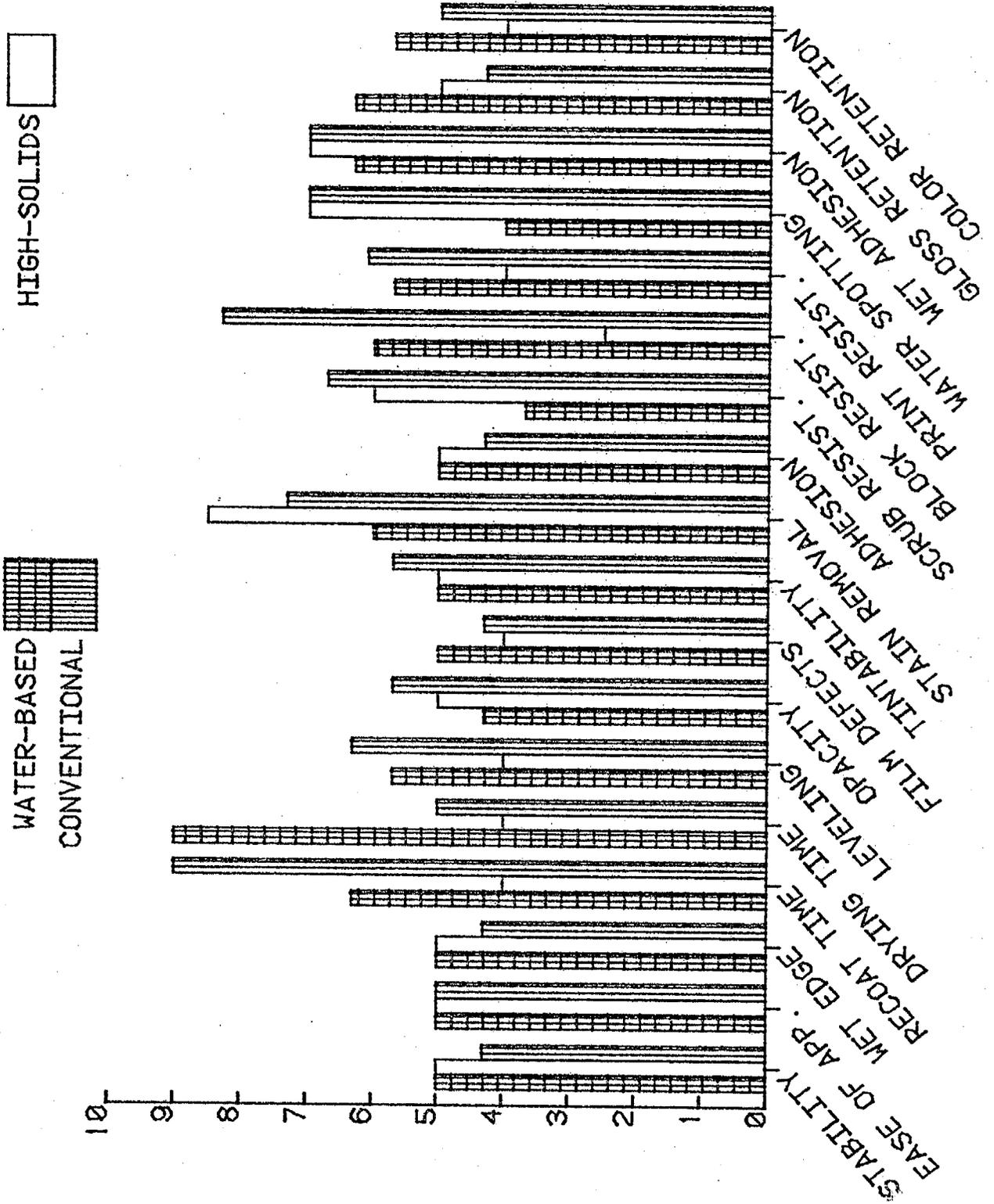
COMPARISON OF "OVERALL PRODUCT AVERAGE" PERFORMANCE RATINGS FOR WATER-BASED, HIGH-SOLIDS AND CONVENTIONAL INTERIOR ENAMELS



DL LAB TEST RATINGS

Graph 2

COMPARISON OF "BEST PRODUCTS AVERAGE" PERFORMANCE RATINGS  
FOR WATER-BASED, HIGH-SOLIDS AND CONVENTIONAL  
INTERIOR ENAMELS



DL LAB TEST RATINGS

- Storage Stability - Both the WB and HS enamels tended to be slightly better than the conventional enamels.
- Ease of Application - The WB enamels tended to be better than the others. However, the best enamels of each group were equal.
- Wet Edge - The WB enamels tended to be better than the others. However there was no significant difference among the best enamels.
- Recoat Time - Even the best HS enamels were too slow. On the other hand, the best conventional enamels were best of all.
- Drying Speed - Even the best HS and conventional enamels did not approach the drying speed of the WB enamels.
- Leveling - The best WB enamels improved in leveling whereas the HS enamels were poorest, whether overall or among the best products.
- Opacity - The best WB enamels still were not quite equal to the others, especially the best conventional enamels.
- Film Defects - The best WB enamels exhibited a definite improvement whereas the HS enamels, best or overall, were poorest of all.
- Tintability - The best conventional enamels did improve so that they were slightly better than the others.
- Stain Removal - The best WB and HS enamels improved. However, the WB enamels were still inferior, whereas the HS enamels were superior as compared with the best conventional enamels.
- Adhesion (Dry) - The best WB enamels improved considerably until they were equal to the best HS enamels and slightly better than the best conventional enamels.
- Scrub Resistance - The best WB enamels were still inferior to both the best HS and conventional enamels.
- Block Resistance - The best WB enamels improved considerably but still did not equal the conventional enamels. On the other hand, the HS enamels did not improve at all and were definitely poorest of the group.
- Print Resistance - The best WB enamels did improve to essentially equal the conventional enamels. On the other hand, the HS enamels did not improve so that they were inferior to the others.

Water Spotting Resistance - Even the best WB enamels did not improve significantly and were still inferior to both the HS and conventional enamels.

Adhesion (Wet) - The best WB enamels improved considerably but were still slightly inferior to both the HS and conventional enamels.

Gloss Retention - The WB enamels were superior to both the HS and conventional enamels.

Color Retention - The WB enamels were superior to the others, in general. On the other hand, the best HS enamels improved considerably but still were inferior to the others.

#### 5. Comparison of Best Properties

The range of ratings for all rated properties, as well the range of results of all non-rated properties, are shown in Table 7.

Note that the best water based coating for that property was superior to the best conventional enamel for that property in:

Storage stability  
Drying speed  
Opacity  
Gloss retention

and equal in all other rated properties except print resistance which was only slightly inferior (Rating of 7 vs 10).

On the other hand, none of the high solids enamels were superior to the best conventional coating in any property. Instead, the best high solids enamel was inferior to the best conventional enamel in the following properties:

Recoat time  
Leveling  
Opacity  
Tintability  
Scrub resistance  
Block resistance  
Print resistance  
Gloss retention  
Color retention

Table 7  
Range of Properties

		<u>Water Based</u>	<u>High Solids</u>	<u>Conventional</u>
Weight per Gallon	Lbs.	9.7-12.2	10.4-12.1	9.4-11.6
Total Solids	%	40.1-62.5	71.2-81.9	62.3-73.9
Viscosity	KU	62-98	71-95	67-110
Storage Stability	Rating	10-3	5	5-0
Application Ease	Rating	5-3	5-0	5-0
Coverage - Primed	Ft <sup>2</sup> /gal	400-525	330-430	320-490
- Unprimed	"	310-450	305-405	260-450
Wet Edge	Rating	5-3	5-3	5-0
Recoat Time	Rating	10-5	5-3	10-3
Drying Speed	Rating	10-5	5-3	5-3
Leveling	Rating	7-0	5-3	7-3
Gloss - 60°	Unit	21-90	61-80	30-90
Opacity	Rating	10-0	5	7-3
Film Defects	Rating	5-0	5-3	5-3
Tintability	Rating	7-0	5	7-0
Stain Removal	Rating	10-0	10-5	10-5
Adhesion (Dry)	Rating	5-0	5	5-3
Scrub Resistance	Rating	10-0	7-0	10-3
Block Resistance	Rating	10-0	5-0	10-0
Print Resistance	Rating	7-0	7-3	10-3
Water Spotting	Rating	7-0	7-5	7-5
Adhesion (Wet)	Rating	7-0	7	7
Gloss Retention	Rating	10-5	5-3	7-3
Color Retention	Rating	7-5	5-0	7-3

6. Non-Rated Properties

The non-rated properties are also of interest:

- Weight per gallon - About the same range for all.
- Total solids - WB coatings tended to be lower and HS coatings higher than the conventional products.
- Viscosity - Essentially the same.
- Coverage -  
    Primed - WB enamels had higher coverage rates than the other coatings because of their superior ease of application (Aver. = 5.0 vs 4.0 for conventional) and HS enamels had lower coverage rates because of more difficult application (Aver. = 3.3).
- Unprimed - All of the enamels had equivalent and lower coverage rates since the porosity of the surface overshadowed the relative ease of application.
- Gloss - The WB coatings tended to have a lower average gloss and the HS coatings tended to have a higher average gloss than the conventional enamels.

7. Effect of VOC, Gloss and Price

The effect of VOC level, gloss and price can most readily be determined by comparing them for the best proprietary enamels tested. The data for these products are repeated in Table 8.

VOC Level - It is evident that all levels were above 250 grams per liter.

Gloss - Gloss level in itself, did not appear to have a major impact on performance although a higher gloss seemed to be beneficial.

The gloss levels of the water based coatings varied from 42, below the overall group average of 55, to 84, the highest of the group. Among the high solids enamels, gloss levels were 78 and 80, both slightly above the average of 74 for the group.

Table 8

VOC, Gloss, Price

<u>Best Coatings</u>	<u>VOC (g/l)</u>	<u>Gloss</u>	<u>Price (\$/gal)</u>
<u>Water Based</u>			
No. 5	310	54	17
No. 17	262	84	29
No. 19	258	42	19
<u>High Solids</u>			
No. 27	349	78	18*
No. 30	346	80	14*
<u>Conventional</u>			
No. 6	434	66	18*
No. 9	417	90	22*
No. 26	361	43	17*
<u>Average Values of all Coatings</u>			
Water Based		55	17
High Solids		74	20*
Conventional		60	20*

\* Includes \$1 per gal. for thinning and cleaning solvent

Price Per Gallon - The best water based enamels varied from \$17 to \$29 per gal., either equal to or higher than the overall average of \$17 for the group and \$20 per gal. for the best conventional enamels. The best high solids enamels varied from \$14 to \$18 per gal. lower than the average price of \$20 per gal. both for the group and for the conventional enamels. The best conventional enamels varied from \$17 to \$22 per gal. straddling the group average of \$20 per gal.

8. Relative Importance of Properties

Although no weight has been assigned to the rating for any property, it is evident that some properties are of major importance regardless of end use; others are important for specific end uses.

The relative importance of each of the rated properties for major end uses, where wall enamels are used, is shown in Table 9.

Note that these designations are based on the collective opinion of the writers. They should not be construed to be widely accepted since neither consumers nor paint manufacturers agree as to the relative importance of any paint property or group of properties.

An example of the importance of specific properties is product No. 18 which would be an excellent enamel except for its unacceptable Opacity, a major property regardless of end use.

Table 9

Importance of Properties

End Use ----->	<u>Kitchen</u>	<u>Bathroom</u>	<u>Woodwork</u>	<u>Shelving</u>
Application Ease	X	X	o	o
Wet Edge	X	X	o	o
Recoat Time	X	X	X	X
Drying Speed	X	X	X	X
Leveling	X	X	X	X
Gloss	o	o	o	o
Opacity	X	X	X	X
Film Defects	X	X	X	X
Tintability	X	X	X	X
Stain Removal	X	o	X	X
Adhesion (Dry)	X	X	X	X
Scrub Resistance	X	o	X	X
Block Resistance	o	o	X	X
Print Resistance	o	o	o	o
Water Spotting	X	X	o	X
Adhesion (Wet)	X	X	o	X
Gloss Retention	o	o	o	o
Color Retention	X	X	X	o

X - Major Importance  
o - Minor Importance

The low VOC coatings have been compared in Table 10 for relative overall performance, within the group, for specific applications.

Note that No. 17 and 30 are superior among the low VOC enamels regardless of end use. On the other hand No. 33 would only be superior for use in bathrooms because of its poor scrub resistance.

8. Frequency of Repainting

Frequency of repainting depends on the service life of the applied coating. The properties which might be affected are the following:

- Stain removal
- Scrub resistance
- Adhesion - wet and dry
- Block resistance
- Print resistance
- Water spotting
- Color retention

Although no definite relationship can be determined, it is evident that low VOC enamels tend to be deficient in one or more of these properties and therefore may require more frequent repainting.

Table 10

Overall Performance of Low VOC Enamels

Use ----->	<u>Kitchens</u>	<u>Bathrooms</u>	<u>Woodwork</u>	<u>Shelving</u>
<u>Superior Performance*</u>				
Water Base	17,32	17,32,33	5,17	17
High Solids	30	30	30	30
<u>Acceptable Performance*</u>				
Water Base	19	19,21	19	19
High Solids	27			14

\* Within that group of products only

B. Interior Wall Primers

The ratings of the relative stain sealing qualities of the interior wall primers are shown in Table 6.

Note that the water stain sealing qualities of the water-based primers were inferior to the conventional primers, although there were no essential differences in sealing of the rusty water stains. On the other hand, their grease sealing qualities were decidedly better. This is understandable since the water in the water-based primers will tend to dissolve water soluble stains whereas the solvent in the conventional primers will tend to dissolve greases and oils.

Table 11

Ratings of Interior Wall Primers

	<u>Water Based</u>					<u>Conventional</u>	
	<u>12</u>	<u>19</u>	<u>22</u>	<u>25</u>	<u>45</u>	<u>16</u>	<u>46</u>
From----->	(13)	(7)	(4)	(22)	(9)	(13)	(9)
<u>Water Soluble Stains</u>							
Rusty Water	5	5	5	5	5	5	5
Coffee	0	0	3	5	5	10	10
Tea	3	3	3	7	5	10	10
Grease Stain	10	7	10	7	5	0	0

From - Suppliers of test samples. See report for Contract No. A8-095-31 dated September 22, 1980.

IX GLOSSARY

A simple description of the properties tested will aid in understanding the test results.

Weight per Gallon - Weight of one gallon of paint (Net)

Total Solids - Percentage of the paint which remains after evaporation of all volatile compounds present.

Viscosity - Thickness or fluidity

Viscosity Stability - Retention of viscosity during storage. Four weeks of storage at 125°F is considered to be equivalent to six months of ambient storage.

Storage Stability - Absence of liquid separation, skinning and pigment settling during storage, and the relative ease of remixing the enamel after storage.

Application - The enamel is rolled onto both primed and unprimed surfaces, simulating a typical wall surface.

Coverage - The area covered when the paint is applied by roller.

Application Ease - The ability to apply the paint without excessive drag.

Opacity - The ability of the paint to obscure or hide the surface over which it is applied.

Leveling - Absence of dimple marks from the roller.

Film Defects - Film roughness, craters (holes left by foam produced during the rolling operation).

Wet Edge - The length of time the paint remains wet enough to dissolve into the next coat of a paint, i.e. when rolling onto the adjacent previously painted area.

Recoat Time - The length of time required until the next coat can be applied without damaging the first coat.

Drying Time -

Set to touch - the length of time the paint remains wet to the touch.

Tack free - free of any tackiness. The coating can then be handled carefully.

Dry hard - coating is resistant to normal handling.

Dry thru - coating is hard all the way through to the underneath surface.

Gloss - Shininess or lustre.

Color Acceptance - The relative depth of color when the paint is tinted with a universal tinting color.

Color Development - A measure of tinting color compatability. Depth of color of the paint should not change when rubbed with the finger. This simulates the rubbing effect during application by brush or roller.

Stain Removal - The ease of removing normal stains when the aged paint is scrubbed.

Adhesion to Enamel - Ability of the paint to adhere to a glossy surface such as an enamel.

Scrub Resistance - Resistance of the aged paint to erosion when scrubbed to remove stains.

Blocking - Tendency of the aged paint to stick when warmed. Important for painted shelving and window sills.

Print Resistance - Tendency of the aged paint to lift the print when pressed against a newspaper.

Water Spotting - Tendency of the aged paint to stain when wet with water and then dried.

X CODE AND ABBREVIATIONS

CARB - California Air Resources Board

VOC - Volatile organic compounds (primarily solvents)  
Expressed as grams per liter of paint, less water.

Products Tested

- W-B - Water based
- H-S - High solids - solvent thinned with VOC<350 g/l
- Conv. - Conventional- solvent thinned with VOC>350 g/l
- Polymer- Acr - Acrylic
  - Alk - Alkyd
  - PV - Polyvinyl acetate
  - Mod - Modified
- RMS - Raw material supplier

Discussion of Results

Rating

- 10 = Decidedly above average for all enamels tested
- 7 = Significantly above average
- 5 = Average
- 3 = Significantly below average
- 0 = Decidedly below average for all enamels tested

- L = Low
- H = High
- V = Very

Test Results

<u>Score</u>	<u>Performance</u>	or	<u>Effect</u>
10	Perfect		None
9	Excellent		Trace
8	Very good		Very slight
6	Good		Slight
4	Fair		Moderate
2	Poor		Considerable
1	Very poor		Severe
0	No value		Failed

- Lbs - Pounds
- % - Percent
- KU - Krebs Units
- Ft<sup>2</sup>/gal - Square feet per gallon
- mins - Minutes
- hrs - Hours
- °F - Degrees Fahrenheit
- R.H. - Relative humidity

Appendix I

Interior Wall Enamels - Water Based

Test Results

	<u>1</u>	<u>2</u>	<u>5</u>	<u>8</u>	<u>11</u>	<u>12</u>	<u>17</u>	<u>18</u>	<u>19</u>	<u>21</u>	<u>23</u>	<u>25</u>	<u>29</u>
Weight per Gallon	10.07	10.15	10.16	10.42	10.68	10.38	9.76	9.71	10.68	10.95	12.18	10.90	10.98
Total Solids	40.1	42.8	41.0	48.7	51.2	49.3	42.0	41.2	45.9	51.8	62.5	48.7	54.5
Viscosity													
Initial	91	62	83	66	95	82	62	70	98	83	98	87	95
2 wks @ 125°F	91	64	86	79	104	104	63	68	97	89	96	97	95
4 wks @ 125°F	91	65	86	82	106	106	63	64	93	89	94	101	94
Max. change	0	3	3	16	11	24	1	6	5	6	4	14	1

STORAGE STABILITY Score

2 wks @ 125°F	10	6	8	9	10	9	8	8	9	9	9	8	10
Liquid separation	10	10	10	10	9	10	10	10	10	10	10	8	9
Skinning	10	10	10	10	10	10	10	10	9	10	10	9	9
Settling	10	9	9	10	9	10	9	9	9	9	8	8	9
Ease of re-mix													

4 wks @ 125°F

Liquid separation	10	6	8	9	10	9	8	8	9	9	9	8	10
Skinning	10	10	10	10	9	10	10	10	10	10	8	9	9
Settling	10	10	10	10	10	10	10	10	9	10	10	9	9
Ease of re-mix	10	9	9	10	9	10	9	9	9	9	8	8	9
Wet Adhesion	0	30	100	0	100	100	100	100	80	20	0	90	0

UV EXPOSURE

Gloss - 60°

Initial	21	44	54	49	30	63	84	57	42	40	38	44	64
Exposed	14	37	45	40	24	57	65	48	35	32	24	37	52
Retention	67	84	83	82	80	90	77	84	83	80	63	84	81
Color Retention	10	10	9	9	10	10	10	10	9	10	9	9	10

Test Results

Appendix I

Interior Wall Enamels - Water Based

	<u>1</u>	<u>2</u>	<u>5</u>	<u>8</u>	<u>11</u>	<u>12</u>	<u>17</u>	<u>18</u>	<u>19</u>	<u>21</u>	<u>23</u>	<u>25</u>	<u>29</u>
<b>APPLICATION</b>													
Primed surface													
Coverage Ft <sup>2</sup> /gal	470	480	500	440	430	410	410	460	465	500	475	525	400
Score	10	10	10	10	10	10	10	10	10	10	10	10	10
Ease	2	6	6	4	8	8	2	4	6	8	9	6	6
Opacity	8	8	8	9	6	6	10	10	8	8	8	4	8
Leveling	10	10	10	10	10	10	10	9(b)	10	10	9(b)	9(b)	10
Film defects													
Unprimed surface													
Coverage Ft <sup>2</sup> /gal	410	440	450	330	330	320	330	375	330	340	340	385	310
Score	10	10	10	10	10	10	10	10	10	10	10	10	10
Ease	8	9	10	8	10	10	9	8	9	10	10	10	10
Opacity	8	9	8	10	8	8	10	9	9	9	9	6	6
Leveling	10	10	10	4(a)	10	10	10	10	10	10	9(b)	9(b)	10
Film defects													
Wet Edge													
77°F + 50% R.H.	25	30	30	30	25	25	30	25	20	20	15	25	15
50°F + High R.H.	40	80	85	60	50	60	55	75	40	45	40	55	40
Recoat Time													
77°F + 50% R.H.	25	40	40	35	25	25	30	30	25	25	20	35	25
50°F + High R.H.	60	90	100	90	70	90	70	120	60	75	45	85	70
<b>DRYING TIME</b>													
77°F + 50% R.H.													
Set to touch	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.4	0.2	0.5	0.4
Tack-free	1.2	1.0	2.0	1.4	0.9	1.5	2.0	2.5	3.0	2.5	1.5	4.5	2.5
Dry hard	3.0	2.5	2.5	2.5	2.5	3.0	2.5	2.5	3.5	3.2	1.8	5.5	3.2
Dry thru	3.0	2.5	2.5	2.5	2.5	3.0	2.5	2.5	3.5	3.4	1.8	5.5	3.4
50°F + High R.H.													
Set to touch	2.4	0.5	0.4	0.3	0.3	0.3	0.8	0.8	0.3	0.5	0.3	0.5	0.5
Tack-free	1.8	1.1	22.0	1.5	0.9	1.6	3.3	3.3	3.0	2.7	1.5	4.5	3.5
Dry hard	18.0	4.5	22.0	22.0	4.5	20.0	4.0	4.0	3.6	3.5	2.0	6.0	4.5
Dry thru	18.0	4.5	22.0	22.0	4.5	20.0	4.0	4.0	3.6	3.5	2.0	6.0	4.5

Test Results

Appendix I

Interior Wall Enamels - Water Based

	<u>1</u>	<u>2</u>	<u>5</u>	<u>8</u>	<u>11</u>	<u>12</u>	<u>17</u>	<u>18</u>	<u>19</u>	<u>21</u>	<u>23</u>	<u>25</u>	<u>29</u>
Gloss - 60%	21	44	54	49	30	63	84	57	42	40	38	44	64
Opacity (Drawdown) %	97.6	98.6	99.3	99.0	98.8	98.6	96.6	95.1 <sup>(d)</sup>	98.2	99.0	99.6	98.1	96.6
Color Acceptance	Score												
Red Iron Oxide	4	8	10	6	8	6	10	8	8	4	6	8	2
Phthalo Green	6	10	8	6	10	10	6	9	6	8	9	9	8
Color Development	Score												
Red Iron Oxide	10	10	10	8	9	8	10	10	4	2	6	9	2
Phthalo Green	10	9	10	10	10	10	9	10	10	9	10	10	10
Stain Removal	cycles												
Pencil	250+	7	60	73	32	22	16	30	37	210	140	49	16
Crayon	250+	250+	82	135	160	59	48	60	250	250	160	200	52
Grease	6	3	4	7	6	4	6	25	21	20	38	24	8
Adhesion to Enamel	%	0	100	0	0	0	100	100	100	50	0	0	100
Scrub Resistance	cycles	825	230	585	215	980	655	610	460	720	1260	280	510
Blocking	Score												
Front-to-front	2	4	8	4	0	0	0	0	0	0	0	0	0
Back-to-front	8	4	10	6	4	4	4	6	6	4	0	2	2
Print Resistance	Score	4	4	6	2	2	4	4	4	2	0	2	2
Water Spotting	Score	4(c)	4(c)	2(c)	6	9	10	10	9	8	6	6(c)	9

(a) Film roughness, probably due to paint penetrating on primed porous surface.

(b) Blisters - unbroken foam

(c) Craters

(d) Rechecked with new sample - same result

Appendix I (Cont)

Interior Wall Enamels - Water Based

Test Results

	<u>31</u>		<u>32</u>	<u>33</u>
Weight per Gallon	10.71		10.05	10.74
Total Solids	48.2		43.9	48.4
Viscosity				
Initial	86		100	83
2 wks @ 125°F	89		100	72
4 wks @ 125°F	84		98	71
Max. change	3		2	12

STORAGE STABILITY

2 wks @ 125°F	Score		
Liquid separation	10		4
Skinning	10		9
Settling	10		10
Ease of re-mix	10		6
4 wks @ 125°F	Score		
Liquid separation	9		4
Skinning	9		9
Settling	9		10
Ease of re-mix	9		6

Wet Adhesion	%	100	100	100
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UV EXPOSURE

Gloss - 60°			
Initial	76	84	90
Exposed	64	65	78
Retention	84	77	87
Color Retention	Score	10	10

Appendix I (Cont)

Interior Wall Enamels - Water Based

Test Results

	<u>31</u>	<u>32</u>	<u>33</u>
<u>APPLICATION</u>			
Primed surface			
Coverage	Ft <sup>2</sup> /gal	490	420
Ease	Score	9	8
Opacity	Score	6	9
Leveling	Score	9	10
Film defects	Score	10	10
			*Craters
Unprimed surface			
Coverage	Ft <sup>2</sup> /gal	405	330
Ease	Score	9	8
Opacity	Score	6	9
Leveling	Score	9	10
Film defects	Score	10	10
Wet Edge	mins		
77°F + 50% R.H.	15	20	20
50°F + High R.H.	50	60	55
Recoat Time	mins		
77°F + 50% R.H.	20	25	25
50°F + High R.H.	60	70	65
<u>DRYING TIME</u>			
77°F + 50% R.H.	hrs		
Set to touch	0.2	0.5	0.5
Tack-free	1.2	0.8	24
Dry hard	1.8	0.8	24
Dry thru	1.8	0.8	24
50°F + High R.H.	hrs		
Set to touch	0.2	0.6	2.2
Tack-free	1.2	1.5	36
Dry hard	40	2.5	60
Dry thru	40	5.5	60

Appendix I (Cont)

Test Results

Interior Wall Enamels - Water Based

	<u>31</u>	<u>32</u>	<u>33</u>
Gloss - 60°	76	84	90
Opacity (Drawdown) %	96.8	96.6	96.9
Color Acceptance Score			
Red Iron Oxide	2	6	9
Phthalo Green	6	4	9
Color Development Score			
Red Iron Oxide	2	9	10
Phthalo Green	10	10	10
Stain Removal cycles			
Pencil	19	14	7
Crayon	70	35	13
Grease	7	8	6
Adhesion to Enamel %	100	100	100
Scrub Resistance cycles	815	570	345
Blocking Score			
Front-to-front	0	0	9
Back-to-front	2	0	2
Print Resistance Score	4	2	6
Water Spotting Score	8	10	10

Appendix II

Interior Wall Enamels - High Solids

Test Results

Weight per Gallon	<u>4</u>	<u>14</u>	<u>27</u>	<u>30</u>
	12.08	10.93	10.38	11.92
Total Solids	78.9	81.9	71.2	77.4
Viscosity				
Initial	71	95	90	97
2 wks @ 125°F	82	95	92	119
4 wks @ 125°F	84	104	101	127
	<u>13</u>	<u>9</u>	<u>11</u>	<u>30</u>

STORAGE STABILITY

Score

2 wks @ 125°F  
 Liquid separation  
 Skinning  
 Settling  
 Ease of re-mix

	9	6	9	9
	8	8	9	8
	10	10	10	9
	10	8	9	8

4 wks @ 125°F  
 Liquid separation  
 Skinning  
 Settling  
 Ease of re-mix

	9	6	9	9
	8	8	9	8
	9	10	10	9
	9	8	9	8

Wet adhesion

	100	100	100	100
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UV EXPOSURE

Gloss - 60°

Initial  
 Exposed  
 Retention

	61	78	78	80
	29	37	54	54
	48	47	69	68

Color Retention

	4	4	6	9
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Appendix II

Interior Wall Enamels - High Solids

Test Results

Gloss - 60°	4	14	27	30
	61	78	78	80
Opacity (Drawdown)	97.1	97.5	97.4	98.6
Color Acceptance	Score			
Red Iron Oxide	10	10	8	8
Phthalo Green	6	9	8	9
Color Development	Score			
Red Iron Oxide	10	6	8	6
Phthalo Green	10	10	10	10
Stain Removal	cycles			
Pencil	35	33	22	17
Crayon	40	78	55	45
Grease	19	18	19	12
Adhesion to Enamel	%	100	100	100
Scrub Resistance	Score	345	940	650
Blocking	Score			
Front-to-front	2	0	0	0
Back-to-front	8	6	2	6
Print Resistance	Score	6	2	4
Water Spot Resistance	Score	9	10	10

(a) Film roughness, probably due to paint penetrating unprimed porous surface.

Appendix III

Interior Wall Enamels - Conventional

Test Results

	3	6	7	9	10	13	15	20	22	26
Weight per Gallon	11.61	10.00	10.61	9.68	10.61	10.48	9.37	10.82	10.09	11.22
Total Solids	%	73.9	63.8	62.3	64.1	66.8	62.8	67.8	63.1	73.2
Viscosity	KU									
Initial	93	70	67	97	104	103	98	102	86	110
2 wks @ 125°F	103	83	74	122	131	116	141	108	95	111
4 wks @ 125°F	108	97	75	124	135	122	*	112	95	113
Max. change	<u>15</u>	<u>27</u>	<u>8</u>	<u>27</u>	<u>31</u>	<u>19</u>		<u>10</u>	<u>9</u>	<u>3</u>

STORAGE STABILITY Score

2 wks @ 125°F	9	6	6	8	9	9	9	9	8	9
Liquid separation	8	8	8	4	6	6	6	8	8	8
Skinning	10	10	10	9	10	10	10	9	10	10
Ease of re-mix	10	8	9	8	10	9	9	9	9	8
4 wks @ 125°F	9	6	6	8	9	9	*	9	8	9
Liquid separation	6	8	8	4	6	4	4	8	8	8
Skinning	10	10	10	9	10	10	10	9	10	10
Ease of re-mix	10	8	9	8	10	9	9	9	9	8

Wet Adhesion	%	100	100	100	100	100	100	100	100	100
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UV EXPOSURE

Gloss - 60°										
Initial	36	66	65	90	36	30	90	56	83	43
Exposed	24	31	29	70	27	18	73	42	48	25
Retention	%	47	45	78	75	60	81	75	58	58
Color Retention	Score	8	8	9	8	9	6	10	9	9

\* Coagulated



Appendix III

Interior Wall Enamels - Conventional

Gloss - 60°	3	6	7	9	10	13	15	20	22	26
	36	66	65	90	36	30	90	56	83	43
Opacity (Drawdown)	96.9	98.7	98.7	97.5	98.2	97.6	97.3	98.8	98.9	98.3
Color Acceptance	Score									
Red Iron Oxide	9	9	10	6	8	6	9	6	4	8
Phthalo Green	9	10	9	6	9	6	9	9	4	10
Color Development	Score									
Red Iron Oxide	10	9	9	4	8	4	10	4	2	9
Phthalo Green	10	10	9	10	9	10	10	9	10	10
Stain Removal	cycles									
Pencil	53	38	34	12	34	47	21	21	20	26
Crayon	95	38	46	40	61	69	57	47	43	52
Grease	28	12	15	9	20	23	17	29	26	28
Adhesion to Enamel	%	100	100	85	100	100	100	100	100	100
Scrub Resistance	cycles	520	570	485	1160	630	615	780	990	910
Blocking	Score									
Front-to-front	6	8	8	10	10	6	0	0	0	0
Back-to-front	10	8	10	10	10	8	2	6	4	8
Print Resistance	Score	6	4	6	6	6	2	4	4	4
Water Spot Resistance	Score	9	10	10	10	10	10	10	10	10

(a) Film roughness, probably due to paint penetrating unprimed porous surface.

Test Results

Appendix IV

Interior Wall Primers

Stain	From----->	Water-Based			Conventional			
		12 (13)	19 (7)	22 (4)	25 (22)	45 (9)	16 (13)	46 (9)
Rusty Water	Score	9	10	10	10	10	10	10
Coffee	Score	2	2	4	6	6	10	10
Tea	Score	4	4	4	8	6	10	10
Grease	Score	10	8	10	9	6	0	2

Note: All primers are white in color

From - Supplier of test sample. See report on Contract No. A8-095-31, dated September 22, 1980.

Appendix V

TEST PROCEDURE

The following test methods were used, except as noted in the test conducted:

ASTM D ---- refers to methods described in Part 27 "Paint - Tests for Formulated Products and Applied Coatings" issued by the American Society for Testing and Materials, Philadelphia, PA.

Method ---- refers to tests described in Federal Standard No. 141A "Methods for Testing of Paint, Varnish, Lacquer and Related Materials" issued by the General Services Administration, Washington, DC.

Other tests are described.

A. Interior Wall Enamels

1. Weight per Gallon Unit - Lbs.  
ASTM D-1475 "Density of Paint, Varnish, Lacquer and Related Products".
2. Total Solids Unit - %  
ASTM D-2369 "Volatile Content of Paints".
3. Viscosity Unit - KU  
ASTM D-562 "Consistency of Paints Using the Stormer Viscometer".
4. Viscosity Stability Unit - KU  
ASTM D-1849 "Package Stability of Paint". Viscosity was re-determined after storage.
5. Storage Stability Unit - Score  
ASTM D-1849 "Package Stability of Paint".
6. Application
  - (a) Ease of Application Unit - Score  
Brush the coating on an appropriate substrate and rate for relative ease of application.



12. Stain Removal Unit - Cycles

Drawdown coating on a black Leneta panel and allow to dry for one week. Apply the following stains:

Pencil  
Crayon  
Grease

Allow to stand for 16 hours. Then wash using ASTM D-3450 "Test for Washability Properties of Interior Architectural Coatings".

13. Adhesion to Enamel (Dry) Unit - %

ASTM D-3359 "Measuring Adhesion by Tape Test".

14. Scrub Resistance Unit - Cycles

ASTM D-2486 "Test for Scrub Resistance of Interior Latex Flat Wall Paints".

15. Resistance to Blocking

Apply coating to three square panels about 2" x 2" and allow to dry for 2 days. Place coated panels face to face and face to back. Place in an oven at 120°F under a total weight of 8 lbs. Allow to stand for 24 hours. Remove from oven, allow to cool and observe any sticking of the coating both face to face and to the uncoated back of the block.

16. Print Resistance

Repeat above resting coated block on a sheet of newspaper.

17. Resistance to Water Spotting

Allow coating to dry for 24 hours. Place 3 mils of water on the coating to form a large pool. Cover with a watch glass for 1 hour. Remove watch glass and raise panel slowly so that the water runs down the full length of the coating. Allow to dry for 24 hours. Record any changes in appearance.

18. Adhesion (Wet) Unit - %

Drawdown alkyd enamel on Leneta chart and dry for 7 days. Apply 3 mil (wet) drawdown of test enamel on the alkyd enamel and dry for 3 days. Place 2" X 2" sponge on coating and wet completely. Allow to stand for 20 mins, then remove and pat dry.

Cut a line through the wetted area of the coating, place No. 600 3M transparent tape across and perpendicular to the cut. Press down smooth. Immediately pull the tape off rapidly. Record area of test enamel remaining adhered to the alkyd enamel.

19. Gloss Retention No Unit

Allow coating to dry for one week. Expose to ultraviolet light for two weeks. Record gloss - before and after exposure.

20. Color Retention Unit - Score

Allow coating to dry for one week. Expose to ultraviolet light for two weeks. Observe change in color.

B. Interior Wall Primers

1. Stain Application:

- (a) Rusty Water - Heat water & steel panels at 175 F until water is rusty. Apply 2cc of stain to surface to be primed.
- (b) Coffee - Dissolve Instant Coffee in hot water. Apply 1cc of stain to surface to be primed.
- (c) Tea - Steep tea bag in hot water for 10 minutes. Apply 1cc of stain to surface to be primed.
- (d) Grease - Spread 1cc of Crisco onto surface to form a thin film.

2. Coating Application:

24 hours after the stains have been applied, brush out the test primer on the stained surfaces.

Evaluate panels 10 days after the primer has been applied.

3. Score relative obliteration of stains.

\*00002319\*



**ASSET**