INDIAN BUILDING PAINTS

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INTRODUCTION

Protection and decoration are the end uses of building paints; however, consistency (flow properties), application, and film forming characteristics are also important. In fact these properties influence, directly or indirectly, the protective and decorative values of the dried film. Also, the flow properties of pigment dispersions come into play at various stages of paint manufacture, its packaging, storage and application. Consistency is in turn influenced by many factors, both physical and chemical, and to obtain a uniform product adequate testing and production control are essential.

Specifications for paint products are laid down to ensure a minimum standard of quality and also to serve as a guide to the purchaser and the manufacturer alike. From the manufacturer's point of view producing paints to specifications means formulation, testing, modification, and more testing employing skilled personnel and time consuming methods. This naturally adds to the cost of the product, especially so where small quantities are involved, which the purchaser should not mind if he wants a guaranteed product. However, the chances of the specifications remaining incomplete or ambiguous cannot be ruled out. Take for instance the particular case of consistency. The widely accpted definition of consistency as proposed by Bingham[1] is as follows:

> "Consistency is the property of a material by virtue of which it resists a permanent change of shape and is defined by the complete force-flow relation."

It will be interesting to see how this has been dealt by the Indian and foreign Standards Institutions.

	Indian Standards Institution (IS: 101-1950)	British Standards Institution (BS: 1033-1942)	American Society for Testing Materials (ASTM D: 562-47)
i)	**Definition** "The material shall be in such a condition that stirring easily produces a paint ready for application by the method described in detailed standard"	"The paint shall be in such a condition that stirring easily produces a smooth, uniform paint suitable for application by the method appropriate to the type of paint"	"For the purpose of this method consistency is expressed in terms of the weight required to produce the specified speed". (200 rpm of the rotor)
ii)	**Instruments prescribed** Nil	Flow cup	i) Stormer viscosimeter ii) Flow cup (tentatively recommended vide ASTM D: 1200-52T)
iii)	**Limits** Nil	18-24 seconds in the case of dipping paints type I	Nil

In the light of the above it is seen that the principle of the force-flow relation as an expression of consistency is embodied only in the ASTM procedure*. The B. S. S. recommends the use of a single-point method. The Indian Standard Specifications do not lay down any procedure for measuring consistency. In view of the different procedures and instruments used and also the non-availability of data on flow properties of Indian paints, the need for such a study was keenly felt. Some investigations on the consistency characteristics of some Indian commercial paints have been carried

* The time in seconds for 100 revolutions of the rotor is plotted against the load in grams and from the curve the the load required for 100 revolutions of the rotor in 30 seconds is found out.

out in the Central Building Research Institute, and a report is to be printed in the ISI Bulletin.

In the present paper the consistency characteristics of 38 samples of paints, manufactured to IS Specifications, commonly used for the protection and decoration of buildings were investigated. The single-point and the multiple-point methods have been used. The consistency of the samples was measured by (a) Flow Cup (single-point determination), (b) Gardner Mobilometer and (c) MacMichael Viscosimeter for calculating the plastic viscosity and yield values and for the preparation of hysteresis loops. Other related properties such as brushing and levelling, surface tension, weight per gallon etc., have also been determined.

SOURCE OF SAMPLES

The samples purchased were in 15 different shades ranging from light to dark. Eight manufacturers were contacted, but only three agreed to supply the desired products. Two firms supplied all the fifteen types whilst the third supplied only eight. The details regarding the specification number, colour etc., are given in the tables. For obvious reasons the names of the manufacturers are not given but they are designated as I, II, and III. The samples are numbered alphabetically from A to O (except I for which the letter R has been used).

TESTING OF SAMPLES

Flow Properties

a) Consistency By Flow Cup Type B : As consistency is very susceptible to temperature, its determination by flow cup becomes difficult on account of the steady rise in temperature of the efflux stream. To overcome this, the experiments were carried out in an air conditioned room and the temperature of the efflux stream was maintained at 25° ± 0.5°C. By this method consistent results could be obtained. The consistency is expressed in seconds from the time of efflux till the first distinct break occurs in the efflux stream.

b) Consistency By Mobilometer : The mobility of the samples was measured in seconds by the Gardner Mobilometer at 25° ± 0.5°C.

The time for travel of 10 cm. under 100 g. load was noted. This is one mode of expressing the mobility in arbitrary units. Next the time for 10 cm. travel under different load was determined and the results expressed as time-load curves. For example Fig. 1 and 2 show the consistency curves for the various samples of Firm III. Similar curves have been obtained for the remaining samples.

c) Consistency By MacMichael Viscosimeter : The double consistency curves were prepared by the Pryce-Jones[2] method, using the MacMichael Viscosimeter. In the present investigation wire No. 30 (calibrated) with 1 cm. diameter pluger submerged to a depth of 3 cm. was used. All measurements were carried out at 25° ± 0.5°C. The speed of the cup was varied from 10 to 40 rpm. The hysteresis loops were prepared by plotting rpm against deflections. The intercept made by the down curve multiplied by the instrument constant gives the yield value of the samples.

Other Properties : Besides the above determinations, the following properties have also been investigated :

a) Surface tension – by DuNouy's Tensiometer ;

b) Weight per gallon by gallon weight cup at 25° ± 0.5°C;

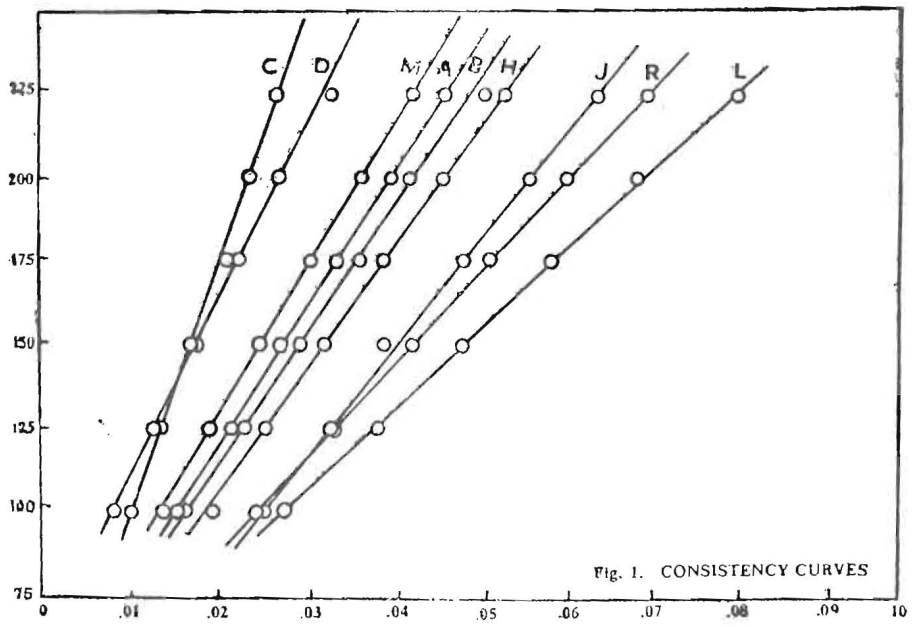

Fig. 1. CONSISTENCY CURVES

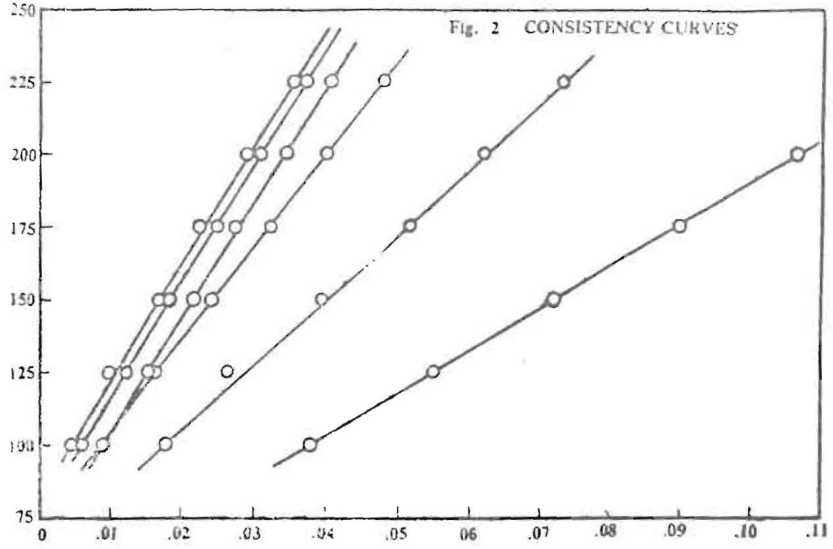

Fig. 2 CONSISTENCY CURVES

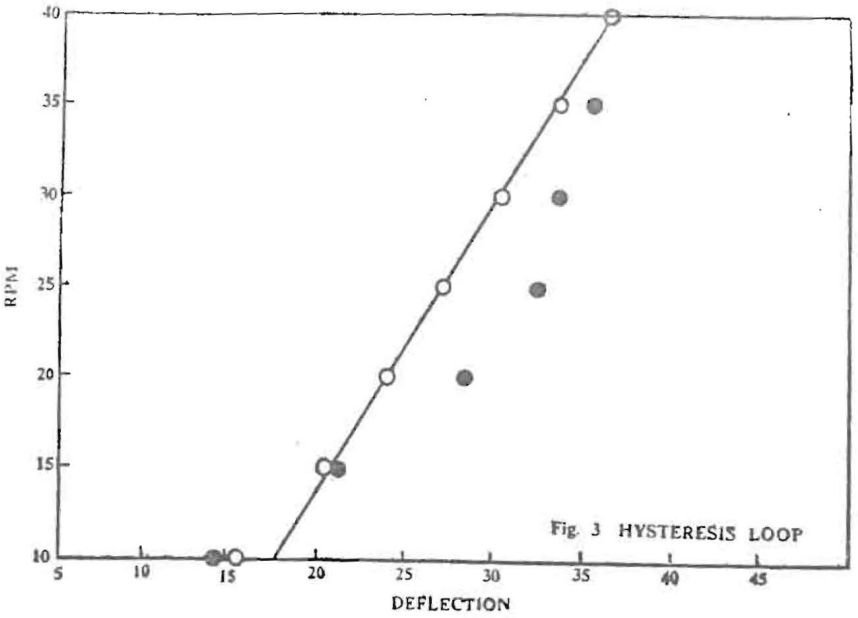

Fig. 3 HYSTERESIS LOOP

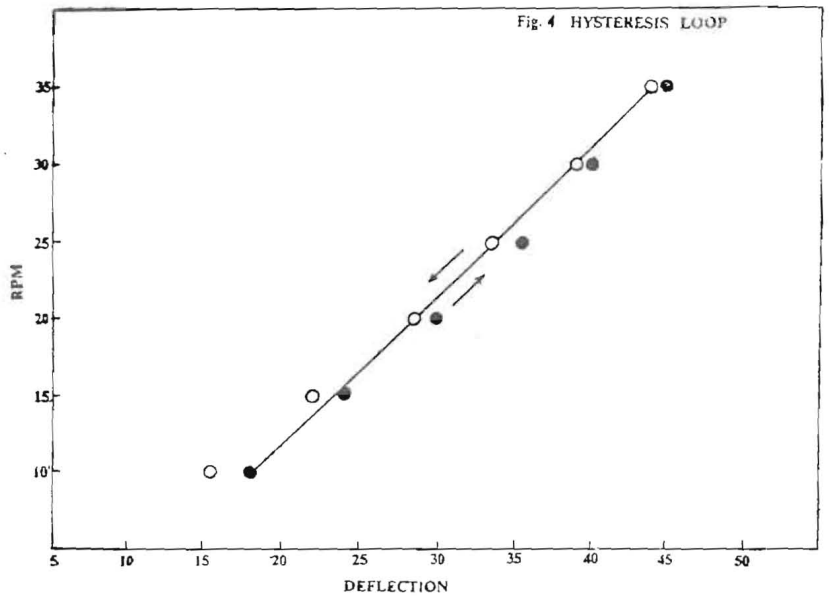

Fig. 4 HYSTERESIS LOOP

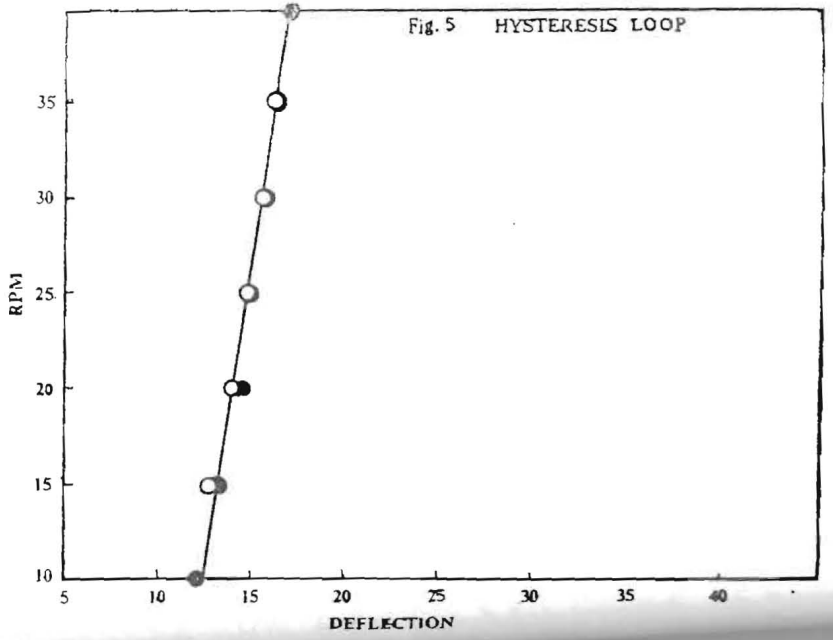

Fig. 5 HYSTERESIS LOOP

c) 60-Deg. Specular Gloss—by Gardner Glossmeter : according to ASTM D:523 – 53T.

d) Brushability and levelling-evaluation by actual brushing.

DISCUSSION OF RESULTS

FLOW CHARACTERISTICS : For the sake of convenience the results for the blue and green paints are given in Table I and those for other paints in Table II. The flow properties of all the paints are summarised in Table III. Figures in column 3 are given to first place of decimal and those in columns 4, 5, and 6 are to the nearest whole number. Grouping of samples in column 2 is based on their yield values.

All the samples possessed uniform consistency as shown by the straight-line nature of the force-flow relation. In general the plastic viscosity of the samples varied between 1.1 to 4.5 poises i. e. well within the limit of plastic viscosity. The consistency, as expressed in Flow Cup seconds and mobilometer seconds were found to be between 26 and 577 and 7 and 114, respectively. Similar limits are not reported in the literature. Seventeen samples were found to possess yield values less than 550 dynes/sq cm; 11 samples between 598 and 826 dynes/sq cm and the rest had values well over 100 i. e. between 1100 and 2779 dynes/sq. cm. In spite of the high yield values of samples B and M from Firm III, acceptable brushing properties were noticed.

BRUSHING QUALITIES : The gradation of the samples in respect of brushing qualities was judged

TABLE I : PROPERTIES OF PAINTS — BLUE AND GREEN

Sample	Description	Firm	Plastic viscosity (poises) at 25°C	Time in seconds for 10 cm travel under 100 g load mobilometer at 25°C	Time in seconds Flow Cup Type B at 25°C	Yield value dynes/sq. cm.	Surface tension dynes/cm. at 25°C	Wt/gallon (Imperial) in lb at 25°C	60 Degree specular Gloss
C	Royal Blue to I:S125—1950	I	3.68	71.5	190.6	598.0	35.4	17.32	70.0
		II	—	—	No sample	—	—	—	—
		III	3.90	92.3	339.5	703.6	34.4	16.18	77.0
D	Oxford Blue to IS:124-1950	I	3.24	—	402.0	1953.0	35.8	17.45	71.0
		II	—	—	No sample	—	—	—	—
		III	2.35	114.1	407.5	2164.0	36.2	16.40	70.0
M	Azure Blue to IS:117–1950	I	2.61	40.8	141.9	633.3	35.0	18.18	79.0
		II	—	—	No sample	—	—	—	—
		III	3.02	68.4	256.8	1100.0	35.6	16.55	77.0
H	Grass Green to IS:119–1950 Class A	I	3.27	35.6	124.0	422.2	35.0	18.22	81.0
		II	4.46	65.2	244.4	334.2	35.4	17.85	71.0
		III	2.96	49.4	193.5	642.2	36.4	17.08	70.0
R	Olive Green to IS:119–1950 Class A	I	3.78	41.9	152.5	351.8	35.3	17.71	74.0
		II	—	—	No sample	—	—	—	—
		III	3.12	39.9	183.0	545.2	35.8	15.26	70.0
J	Brilliant Green to IS:119–1950 Class B	I	3.15	29.95	100.2	343.0	35.2	18.43	71.0
		II	4.14	28.8	110.5	175.9	35.5	16.55	66.0
		III	4.03	38.85	151.0	263.8	36.1	16.33	69.0
K	Middle Brunswick Green to IS:119–1950 Class B	I	3.53	70.5	239.75	606.8	35.5	18.66	60.0
		II	2.55	11.8	50.5	184.7	34.7	15.75	—
		III	3.51	52.3	176.5	413.3	36.4	17.29	74.0

TABLE II

Properties of Paints—other than Blue and Green

Sample	Description	Firm	Plastic viscosity (poises) at 25°C	Time in seconds for 10 cm travel under 100g load mobilometer at 25°C	Time in seconds Flow Cup Type B at 25°C	Yield value dynes/sq cm	Surface tension dynes/cm at 25°C	Wt/gallon (imperial) in lb at 25°C	60 Degree specular Gloss
A	Black to IS:128—1950	I	3.33	47.5	240.0	642.1	35.2	14.19	78.0
		II	2.79	27.5	124.2	378.2	34.5	14.45	79.0
		III	2.71	62.5	293.8	826.8	38.4	14.83	72.0
B	White to IS:127—1950	I	2.42	31.8	96.2	642.1	36.1	20.76	89.0
		II	1.29	16.4	34.3	686.0	38.2	18.23	73.0
		III	1.71	59.5	211.2	2340.0	36.2	18.23	77.0
L	Portland Stone to IS:117—1950	I	2.81	71.5	353.3	1248.0	36.2	17.83	80.0
		II	—	—	— No sample	—	—	—	—
		III	3.23	35.3	119.4	615.6	35.7	17.29	71.1
N	Dark Admiralty Grey to IS:117—1950	I	2.95	90.9	387.5	1284.0	36.1	17.28	77.0
		II	2.98	7.2	26.2	114.4	32.9	18.54	72.0
		III	3.16	52.4	186.0	518.8	36.1	17.44	71.0
O	Slate to IS:117—1950	I	2.70	84.5	372.5	1398.0	36.1	17.29	71.0
		II	—	—	— No sample	—	—	—	—
		III	1.99	20.9	77.2	518.8	36.0	17.59	76.0
E	Red Oxide to IS:123—1950	I	3.28	34.8	158.5	518.8	36.1	16.64	78.0
		II	1.32	7.3	34.9	431.0	37.35	16.56	77.0
		III	2.52	68.5	323.5	1671.0	36.1	16.11	80.0
G	Post Office Red to IS:120—1950	I	1.11	—	558.0	2779.0	—	17.21	—
		II	2.47	26 9	108.4	387.0	35.7	16.22	84.0
		III	1.57	36.0	146.2	668.5	38.2	17.18	82.0
F	Dark Brown to IS:122—1950	I	3.86	54.2	189.7	413.3	36.7	17.73	54.0
		II	—	—	— No sample	—	—	—	—
		III	—	62.5	577.7	—	36.8	15.68	80.0

by the personal experience of the worker. The results are given in Table IV. Firm II supplied only 8 samples, and hence these have not been taken into consideration in comparing with samples from the other two firms. The samples have been rated by using two stars for acceptable performance and one star for inferior performance.

In general the brushing qualities of the samples from all the firms could be correlated with plastic viscosity (Table IV). Samples between 2.42—4.5 poises were found to possess acceptable brushing qualities. Samples L, N, and O of Firm I, although showing inferior brushing qualities fall within the proposed limit. These three samples possessed high yield values, and the inferior brushing performance may be attributed to these high values. Sample G (Firm I) showed inferior brushing qualities, both on the basis of low plastic viscosity (1.11) and very high yield value (2779).

It is interesting to note that high yield values coupled with low plastic viscosity invariably resulted in poorer brushing performance. For example, samples B and D (Firm III) and G (Firm I) were found to possess inferior brushing qualities.

TABLE III

Summary of Flow Properties of Paints

Firm No.	Sample No.	Plastic Viscosity (Poises*)	Flow Cup (Seconds)	Mobilometer (Seconds)	Yield value (dynes/sq. cm.)**	Thixotropy
1	2	3	4	5	6	7
I	E F H R J	3.1—3.8	100—190	35—54	343—519	Very slight to slight
,,	A B C K M	2.4—3.6	96—240	32—72	598—642	Slight to medium
,,	D G L N O	1.1—3.2	373—402	72—90	1248—2779	Medium to marked
II	A E G H J K N	1.3—4.4	26—244	7—65	114—431	Very slight to medium
,,	B	1.2	34	16	686	Slight
III	R J K N O	1.9—4.0	77—186	21—52	264—545	Slight
,,	A C G H L	1.9—3.9	119—340	35—92	616—827	Slight to marked
,,	B D E M F	1.7—3.0	211—577	60—114	1100—2340	Medium

* Limit given in literature, 1-5 poises.

** Limit given in literature, 50-550 dynes/sq cm.

Paint samples, Oxford Blue, Post Office Red and Slates from Firms I and III possessed unacceptable brushing properties. The Oxford Blue paints possessed very high yield values. The Post Office Red paints possessed low plastic viscosity, in addition to high yield value (Firm I). The Slate paint (Firm I) possessed high yield value and that from Firm III low plastic viscosity.

Similar gradation of the samples, with an occasional exception, in respect of brushing performance is obtained on the basis of consistency measured by using Flow Cup and Mobilometer as given in Table V. The results obtained on both the instruments are more or less parallel. However, it will be seen from the results that the range obtained on the Mobilometer is narrow and the samples from all the three firms fall within this range. In addition, a precise control of temperature can be maintained on account of the large integral water bath in the case of Mobilometer. With this instrument, the multiple-point method of measurement can also be adopted and a force-flow relation drawn. In view of these advantages, the use of the Mobilometer is preferred to the Flow Cup.

LEVELLING QUALITIES: In general it was observed, as shown in Table VI, that the products from Firm II were less thixotropic than those from the other two firms. Levelling qualities were found to follow the order of the area of the hysteresis loops (Table II). On the basis of the area of these loops it is noticed that samples could be divided into distinct groups in respect of levelling performance. Samples showing inferior levelling properties exhibited either very large area (Fig 3) or too small (almost negligible) area (Fig 5); those with medium area (Fig 4) showed good performance. Three samples with high surface tension (above 37 dynes/sq cm) resulted in inferior levelling properties. It may also be noticed that samples possessing inferior levelling qualities, possessed high yield values (Tables I and II).

RECOMMENDED LIMITS

Evaluation of brushing and levelling properties of Indian commercial paints have been reported* from this Institute, in an earlier investigation using two instruments only. A limit of 2.5 to 4.5 poises of plastic viscosity was found to result in good brushing properties. Williamson and Co-workers[3] found that paints with acceptable brushing qualities were between 2 and 5 poises. Droste[4] reports a range of 3.5 to 4.0 poises, and yield values between 400 and 1,400 dynes/sq cm for paints with acceptable brushing qualities. As already indicated in the introduction an attempt has been made in the present investigation to correlate the rheological data with brushing qualities, with a view to suggest a suitable instrument and indicate limits within which the values should fall for acceptable brushing properties.

* Under print in Indian Standards Institution Bulletin

TABLE IV

Brushability and Consistency (Poises)

ample	Plastic Viscosity (Poises)	Brushability gradation
FIRM I		
F	3.86	**
R	3.78	**
C	3.68	**
K	3.53	**
A	3.33	**
E	3.28	**
H	3.27	**
D	3.24	**
J	3.15	**
N	2.95	*
L	2.81	*
O	2.70	*
M	2.61	**
B	2.42	**
G	1.11	*
FIRM II		
H	4.46	**
J	4.14	**
N	2.98	*
A	2.79	**
K	2.55	**
G	2.47	**
E	1.32	*
B	1.29	*
FIRM III		
J	4.03	**
C	3.90	*
K	3.51	**
L	3.23	**
N	3.16	**
R	3.12	**
M	3.02	**
H	2.96	**
A	2.71	**
E	2.52	**
D	2.35	*
O	1.99	*
G	1.97	*
B	1.71	*

** Acceptable

* Inferior

In drawing conclusions and proposing tentative its border line cases have been omitted and the its have been slightly widened to include possible nples near about the observed limits. The flow perties of samples (firmwise) possessing acceptable shing are summarised below :

Firm	Plastic Viscosity (Poises)	Flow Cup (Seconds)	Mobilometer (Seconds)	Yield Value (dynes/sq cm,
I	2.4 – 3.9	96 – 240	30 – 72	343 – 642
II	2.5 – 4.5	50 – 245	27 – 65	175 – 387
III	2.5 – 4.0	119 – 340	35 – 69	264 – 827

TABLE V

Brushability and Consistency (Arbitrary Unit)

Flow Cup (Type B)			Mobilometer		
Sample	Seconds	Brush-ability Grada-tion	Sample	Seconds	Brush-ability Grada-tion
FIRM I					
G	558.0	*	N	90.0	*
D	402.0	**	O	84.5	*
N	387.5	*	L	71.5	*
O	372.5	*	C	71.5	**
L	353.5	*	K	70.5	**
A	240.0	**	F	54.2	**
K	239.8	**	A	47.2	**
C	190.6	**	R	41.9	**
F	189.7	**	M	40.8	**
E	158.5	**	H	35.6	**
R	152.5	**	E	35.0	**
M	141.9	**	B	31.8	**
H	124.0	**	J	30.0	**
J	100.1	**	D and G showed excessive skinning and hence omitted		
B	96.2	**			
FIRM II					
H	244.4	††	H	65.2	††
A	124.2	††	J	28.6	††
J	110.5	††	A	27.5	††
G	108.4	††	G	26.9	††
K	50.5	††	B	16.4	†
E	34.9	†	K	11.8	††
B	34.3	†	E	7.3	†
N	26 2	†	N	7.2	†
FIRM III					
F	577.7	†	D	114.1	†
D	407.5	†	C	92.3	†
C	339.5	†	E	68.5	††
E	323.5	††	M	68.4	††
A	239.8	††	A	62.5	††
M	256.8	††	F	62.5	†
B	211.2	†	B	59.5	†
H	193.5	††	N	52.4	††
N	186.0	††	K	52.3	††
R	176.5	††	H	49.4	††
J	151.0	††	R	39.9	††
G	146.2	†	J	38.9	††
L	119.4	††	G	36.0	†
O	77.2	†	L	35.3	††
			O	20.9	†

** or †† Acceptable

* or † Inferior

TABLE VI LEVELLING THIXOTROPY

Gradation on the basis of area of the loop (descending order)	Levelling performance
Firm I	
O	*
N	*
L	*
G	*
D	*
A	**
B	**
C	**
K	**
F	**
E	**
J	**
R	**
H	**
M	**
Firm II	
H	**
A	**
G	**
J	**
K	**
N	**
B	*
E	*
Firm III	
L	*
D	*
E	*
M	**
B	**
A	**
R	**
H	**
O	**
N	**
J	**
K	**
C	*
G	*

** Acceptable
* Inferior.

Natural and accelerated weathering studies on these paints have also been planned. Data for some months' exposure are avilable at present. The results of these studies will be reported at a later date on completion of the study.

CONCLUSIONS

On the basis of the present investigation and the samples studied the following tentative conclusions are drawn :

In order that the paint should possess acceptable brushing properties, the rheological properties of the material should be as under :

a) Plastic viscosity : between 2.4 and 4.5 poises;

b) Consistency as expressed in Mobilometer-seconds : between 25 & 75 seconds;

c) Yield value : between 150 & 850 dynes/sq cm

Mobilometer is preferable for control purpose in the measurement of consistency for reasons given above.

The factual data may serve for choosing values for the "approved sample."

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