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A SYSTEM OF TYPE IDENTIFICATION AND GRADING FOR HOUSE PAINTS

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Foreword

Multiplication of the different kinds of house paint on the market in recent years makes a systematic classification imperative both for their successful use by the public and for progress in paint technology. A plan of identification by type and grade is described in detail. The details are sometimes arbitrary in nature and susceptible of other arrangements but for the present the details should be considered only as necessary means of explaining the basic principles of the plan, its objectives, and its method of approach. That purposeful classification is feasible technically must be recognized before discussion of the minor details becomes profitable. By its nature the proposed plan requires action by the paint industry as a whole, presumably through its trade association; without far reaching co-operative endeavor the plan offers no advantages. It should be emphasized that its ultimate value to the public and to the industry lies not in the mere classification of paints but in the educational program in proper application and maintenance of paint and the facilitation of research in those fields thereby made possible.

Most exterior house paint is used to make coatings that are maintained over a long period of years. Because removal of a coating when worn out is expensive the coating is usually renewed by applying fresh paint over it. After the first repainting, therefore, the composition of the coating is no longer determined entirely by that of the new paint but by that of the new paint plus that of all previous paints minus the changes caused by weathering. Maximum uniformity in composition of the coating and closest conformity to the conditions under which the behavior of coatings has been studied are obtained when the same kind of paint is used throughout the period of maintenance of the coating.

Unfortunately property owners and painters treat each paint job as a separate transaction independent of preceding and succeeding jobs while paint manufacturers formulate their paints entirely independently of one another. The result is that, on great numbers of houses, the coating after a few repaintings becomes a hodgepodge of different paints whose behavior is unpredictable and often turns out to be very bad, though the real cause of the disaster is seldom realized. Nothing can be done to eliminate the uncertainties caused by haphazard combinations of paints until an adequate classification of house paints according to kind is generally recognized and paints are identified by kind as well as by manufacturers' brands. In no other way can numerous kinds of good house paints be sold with a reasonable assurance that each one can be so used that it will give the good service of which it is known to be capable.

The limitations imposed by the necessity of maintaining coatings were recognized as early as 1911 (26)[1] but since that time the subject has been largely overlooked and paint technologists tacitly assume that good paint can be designed without reference to the specific program of maintenance in which it is to be used. Meantime the development of new pigments, new oils, new synthetics, and new formulas multiplies the number of different types of house paint on the market while no measures other than the impracticably complex formula label are adopted to differentiate paints by types.

That the indiscriminate choice of paints and maladjustment of kind of paint to maintenance program are basic causes of dissatisfaction with paint jobs has been discussed at length elsewhere (4). Although many paint manufacturers believe that they receive few "justifiable" complaints from customers (19), early paint failures are numerous enough to undermine public confidence in house paint (20), to call for frequent explanation (15, 20, 23, 29), and to supply the appeal to fear in advertising addressed both to paint makers (11) and to the public (28). Only recently has it been realized that the great majority of user's complaints about paint arise where good paints have been applied to good woods on reasonably well built houses but where paints of different kinds have been used for successive jobs (7). As long as the painter and the public are presented with many kinds of house

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[1] Numbers in parentheses refer to the list of references at the end of the paper.

paint, sold merely as house paint, attempts to tell painters and users of paint how to maintain coatings with reasonable assurance of satisfaction must remain hampered by technical detail about paint composition (3) or evasive of the major issues (25).

A system of classifying paints, directed toward the conditions that determine their successful use, is likewise needed by paint technologists for adequately orienting their technical studies. So far research in paint has been preoccupied with rivalries between competing raw materials and formulas and has been dominated by the idea that the goodness or badness of a paint can be determined entirely on its own merits without regard for the other paints on the market. Exposure tests are evaluated principally from the manufacturers' point of view, which often is not that of the house owner (2), and as a rule are confined to the initial painting of new lumber. Paint research should take on new impetus from a broader conception of its proper scope and of the mutual interest of manufacturer, painter, and owner in learning how to use each kind of paint successfully.

Growing Significance of Volume Relations in Paint

For lack of a practical classification of paints, exposure tests made to study the effects of different pigments and mixtures of pigments on the performance of paint were long characterized by disregard for the content of total pigment in the paint. On the first test fence at the North Dakota Agricultural College in 1906 the paints were commercial products but experimental paints were manufactured for the fence erected in 1907 and for similar fences at Atlantic City and Pittsburgh. Most of the reports of these tests gave the composition of the pigment and of the vehicle of each paint but did not give the proportion of total pigment (10, 13, 14, 30, 33), which varied unsystematically and was evidently considered unimportant. Years later Calbeck (9), following an old theory of MacGregor (27), reworked the data for the tests at North Dakota and pointed out a close connection between content of total pigment by volume and durability of the paints. In an early test by Subcommittee D-1 of the American Society for Testing Materials mixtures of pigments were made by volume rather than by weight but the proportion of total pigment in the paint was established by adding oil until the paint attained an arbitrarily chosen viscosity (34). Since no attempt was made to select pigments of suitable physical properties many of the resulting paints were impractical. Recent studies (12) suggest that measurement of the consistency of a paint as a function of the content of total pigment by volume leads to a "critical point" that is optimum not only for brushing properties but also for durability. The more experienced technologists are now careful to make all paints for comparative exposure tests with a constant proportion of total pigment by volume (1, 24), usually 28 or 29 percent of the total nonvolatile, which appears to be the optimum proportion for most types of white or tinted house paint.

Appreciation of the significance of proportions by volume rather than by weight has gained ground so slowly in paint technology largely because the analyst rather than the technologist dictated the state laws that set the pattern for formula labeling. Analyses are conveniently expressed in percentages by weight. Likewise in manufacturing practice it is more accurate to measure the ingredients of a batch by weight than by volume. To the technologist, however, the formula in percentages by weight is a purely empirical expression incapable of precise evaluation or comparison with similar formulas for other paints. Even for so elementary a purpose as the calculation of costs the yield in volume of each ingredient of the formula must be computed. Most of the useful properties of paint are determined, at least to a first approximation, by the proportions of ingredients by volume. Volume, not weight, governs the area coverable with a film of suitable thickness, the concentration of opaque pigments in the film necessary to hide the surface, and the concentration of total pigments required both for good consistency for application and for optimum durability. Presumably the factors of composition that control the compatibility of paints used successively likewise are expressible in terms of proportions by volume. Since the various pigments and liquids used in paint differ very greatly in specific gravity it is clear that a useful system of classifying paints must be based upon the composition by volume, not that by weight. The specific gravities and bulking values of the pigments and liquids used in house paint are recorded in books of reference (17).

Basic Principles of the Proposed Classification

The system of classifying house paints described herein is a gradual development over a period of approximately five years since its original conception. During that time it has been used for guidance in formulating paints for the studies of the Forest Products Laboratory, for advising correspondents about the relative merits of commercial paint formulas, and for studying the causes of early failures of paints on houses. The details have been elaborated and minor changes made as experience suggested until it now seems adequately rounded out for presentation as far as white paints and tinted paints are concerned. Although the same principles may be applied to classification of house paints made predominantly of colored pigments paints of that kind will not be considered at this time.

The characteristics of a house paint are determined by the nature and proportions of its pigments, the nature and proportions of its liquids, and the concentration of total pigments. Until comparatively recently the nonvolatile liquids in all except some cheap paints consisted essentially of unbodied drying oils, usually linseed oil, containing small additions of driers while the volatile liquids were turpentine, mineral spirits, and water. Substitution of moderate proportions, say 10 percent, of bodied for unbodied drying oils has become fairly common but as long as it does not impart properties of enamel rather than of paint there seems to be no reason for believing that compatibility with other paints and consequently the classification of the paint is thereby altered. The "enamelized", "resin-fortified", and "quick-drying" house paints that have appeared in recent years, however, call for distinction from the true house paints in classification but as yet remain relatively unimportant commercially. The differences in the nature and amount of the pigments remain the center of interest in formulation of house paints and the principal basis for classifying them.

Among the white pigments the zinc oxides and the white leads are generally recognized as "chemically active" pigments in that they profoundly affect the conversion of the liquid drying oils to solid oxyns (31), and impart distinctive properties to the resulting coating. Zinc oxide acts as a hardening agent in paint (8). White lead keeps paint tough and distensible to a late stage in its life (22). Lead titanate, though said to be chemically inert, imparts the same properties to paint (32) and probably should be grouped with the white leads. The titanium pigments and the zinc sulfide pigments are chemically inert (21) as are also the transparent pigments with the possible exception of calcium and magnesium carbonates. The fact that the lead, zinc oxide, and chemically inert pigments differ profoundly in their effects on the behavior of paint is firmly established empirically even though the chemistry of the reactions with the drying oils is still imperfectly understood. Further, empirical evidence is accumulating to the effect that variation in content of zinc oxide is a common cause of incompatibility between paints applied successively (5). For these reasons a classification of the white paints should separate them into groups of reasonably uniform content of the two kinds of chemically active pigments.

From the point of view of opacity of the paint distinction must be drawn between the transparent pigments, the opaque white pigments, and the very opaque white pigments. The transparent pigments, such as silica, the silicates, barium sulfate, and calcium carbonate, add practically nothing to the opacity of the paint, though they are often very useful in building up an optimum content of total pigment for good consistency and durability. The opaque white pigments include the white leads, the zinc oxides and leaded zinc oxides, titanium-barium pigment, lothopone, and antimony oxide. The very opaque white pigments include titanium dioxide, lead titanate, zinc sulfide, the high-strength lithopones, and titanated lithopone.

In the proposed system of classification house paints made with unbodied drying oils are separated into groups of types depending upon the nature of the opaque white pigments, into types depending upon the proportions of the chemically active pigments, and into grades depending upon the concentration of opaque white pigments, total pigments, and total nonvolatile in the paint. Both type identification and grading follow naturally out of practices of the paint industry even though these practices have never been formally recognized. Technologists for some time have distinguished informally between the lead-zinc paints, the titanium-lead-zinc paints, the lithopone-lead-zinc paints, lead-less paints, etc. Likewise it has long been customary to speak of high grade and low grade, or first grade and second grade paints. Although no systematic method of grading is recognized the one proposed conforms closely to the conventional practices dictated by the economics of the situation. The well known differences of opinion about paint formulas so characteristic of the paint industry have to do chiefly with the relative merits of the different groups and types of paint, not so much with the merits of the grades within each type. Since the separation of paints into groups and types carries no implication of comparative merits the existing differences of opinion need not complicate consideration of the proposed system of classification.

Details of the Proposed Classification

Table 1 illustrates the application of the proposed system of type identification and grading to 30 commercial paints made by well known manufacturers. These 30, which are selected from more than 100 prepared paints and 50 paste paints examined, are believed to represent fairly the present range in formulation of prepared white and tinted paints in which the vehicle is predominantly unbodied drying oil. Enamelized, quick-drying, and most resin-fortified paints are excluded. Paint No. 30 is moderately fortified with resin but contains no zinc oxide and has the properties of a true house paint. The use of resin in low grade paints, such as Paints 23, 27, and 28, follows a long tradition of the industry.

In Table 1 the formula of each paint is given first in the manner in which it is commonly expressed on formula labels. The total pigment and total liquid are expressed as a percentage of the paint by weight and the individual pigments and individual liquids as a percentage by weight of the total pigment and of the total liquid, respectively. Under the formula by weight for each paint appears the "volume analysis" of the formula, that is, the fraction of a gallon of each ingredient in 1 gallon of the paint. If multiplied by 100 these figures become percentages by volume. The volume analysis is calculated by much the same procedure commonly followed in computing the yield in gallons of formulas expressed by weight (<u>16</u>). The number of pounds of each ingredient is multiplied by the published bulking value of the ingredient in gallons per pound (<u>17</u>) to find the yield of each in gallons, which is then divided by the total yield.

In the volume analysis subtotals are struck for total opaque pigments, total pigments, and total nonvolatile. When the very opaque pigments are used a sufficient amount of dilution with transparent pigment is included in the subtotal for total opaque pigments to yield the same subtotal that would have been obtained if optically equivalent proportions of titanium-barium pigment (25 percent TiO_2) or regular lithopone (28 percent ZnS) had been used. Thus in Paint 12 the pigment contains 0.035 gallon of titanium dioxide for which 0.091 gallon of diluent is counted as opaque pigment because 0.126 gallon (0.035 + 0.091) of titanium-barium pigment would be required to provide the same amount of titanium dioxide. The diluent for titanium dioxide is calculated by multiplying the volume of titanium dioxide by the factor 2.6 (0.035 x 2.6 = 0.091). The factors for the very opaque pigments are:

Table 1.—Application of the proposed system of type identification and grading to 30 commercial house paints

Paint number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Percentage formula in percent by weight															
Total pigment in paint	60.1	65.1	68	55.0	68	60.9	65.0	67.4	66.8	64.6	61.0	66	66.0	66.2	64.0
Total liquid in paint	39.9	34.9	32	45.0	32	39.1	35.0	32.6	33.2	35.4	39.0	34	34.0	33.8	36.0
Total paint	100.0	100.0	100	100.0	100	100.0	100.0	100.0	100.0	100.0	100.0	100	100.0	100.0	100.0
Pigment composed of															
White lead (carbonate)	50.0	66.6	27	5.0	70	32.2	55.0		80			33.3	14.0		50.0
White lead (sulfate)			23	30.0		19.5		7.5		30.5	18.4	16.2	16.0	15.8	
Zinc oxide	50.0	33.4	40	45.0	30	35.1	30.0	42.9	20	21.8	45.2	29.5	23.5	23.2	23.0
Titanium-barium pigment											27.4		36.5	46.0	18.0
Lead titanate														7.0	
Titanium dioxide												10.0			
Lithopone															
Lithopone, titanated															
Magnesium silicate			8	10.0		13.2	15.0	22.5		10.8	9.0	10.0			9.0
Silica				10.0											
Barium sulfate															
Calcium carbonate								27.1		32.6					
China clay										5.3					
Total pigment	100.0	100.0	100	100.0	100	100.0	100.0	100.0	100	100.0	100.0	100.0	100.0	100.0	100.0
Liquid composed of															
Unbodied drying oils	86.3	81.7	90	90.0	90	89.9	66.0	58.3	88	83.6	73.1	90.0	90.0 }	90.1	86.0
Bodied drying oils											18.4				
Resins															
Turpentine and drier	8.3	9.3			10				9		4.6				
Mineral spirits, drier	5.4	9.0	10	10.0		10.1	14.0	21.2	3	16.4	7.9	10.0	10.0	9.9	14.0
Water								20.5							
Total liquid	100.0	100.0	100	100.0	100	100.0	100.0	100.0	100	100.0	100.0	100.0	100.0	100.0	100.0
Volume analysis, in gallons[1]															
White lead (carbonate)	.083	.131	.068	.007	.154	.053	.103		.170			.067	.035		.091
White lead (sulfate)								.024		.095	.038				
Leaded zinc oxide (35%)			.154	.114		.104						.103	.103	.101	
Zinc oxide, lead-free	.100	.079			.080		.068	.098	.051	.048	.069				.090
Titanium-barium pigment											.071		.113	.146	.052
Lead titanate														.012	
Titanium dioxide												.035			
Lithopone															
Lithopone, titanated															
Diluent allowance[2]												.031		.036	
Total opaque pigments	.183	.210	.216	.121	.234	.157	.171	.106	.221	.098	.198	.236	.251	.297	.193
Magnesium silicate			.041	.032		.052	.068	.096		.044	.035	.046			.039
Silica				.034											
Barium sulfate															
Calcium carbonate								.150		.139					
China clay										.019					
Total pigments	.183	.210	.257	.187	.234	.209	.239	.352	.221	.301	.227	.281	.251	.261	[illegible]
Unbodied drying oils	.694	.690	.656	.718	.684	.698	.637	.368	.678	.566	.557	.662	.662 }	.653	.644
Bodied drying oils											.106				
Resins															
Total nonvolatile	.877	.840	.913	.905	.918	.907	.876	.720	.899	.867	.890	.913	.913	.914	.876
Turpentine and drier	.072	.076			.082				.074		.038				
Mineral spirits, drier	.051	.084	.087	.095		.093	.124	.160	.027	.133	.072	.087	.087	.086	.124
Water								.120							
Total paint	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Characteristics of paint															
Group[3]	LZ	LZ	$(LZ)_n$	$(LZ)_n$	LZ	$(LZ)_n$	$(LZ)_n$	$(LZ)_n$	LZ	$(LZ)_n$	TLZ	TLZ	TLZ	TLZ	TLZ
Zinc oxide in pigment[4]	35	38	40	37	34	34	28	26	23	15	39	26	26	26	22
White lead in pigment[4]	65	62	44	27	66	42	43	4	77	18	16	40	27	17	39
Opaque pigments in total pigment[4]	100	100	64	69	100	75	71	30	100	33	85	118	100	114	83
Total pigment in total nonvolatile[4]	21	25	28	21	26	23	27	49	25	35	25	26	27	29	27
Type and grade of paint															
Type No. (see table 2)	1	2	3	4	5	6	6	7	8	9	10	11	12	13	14
Grade	D	C	B	E	B	D	C	E	C	E	C	A	A	A	C

Paint number	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Percentage formula in percent by weight														Soft paste white lead mixed with 3 gallons of linseed oil and 1 pint of drier per 100 pounds	
Total pigment in paint	64.0	66	61.5	68.3	63	67.0	62.3	58.0	62.0	57.3	58.0	48	50.0		68.3
Total liquid in paint	36.0	34	38.5	31.6	37	33.0	37.7	42.0	38.0	42.7	42.0	52	50.0		31.7
Total paint	100.0	100	100.0	100.0	100	100.0	100.0	100.0	100.0	100.0	100.0	100	100.0		100.0
Pigment composed of															
White lead (carbonate)	37.9	36	19.0	27.0											50
White lead (sulfate)	18.9		15.1	18.0	28	18.3	9.0	7.8							
Zinc oxide	24.6	20	26.0	33.6	26	22.7	16.7	13.1	40.0	40.0	31.0	12			
Titanium-barium pigment		37	49.9								33.6		19		50
Lead titanate															
Titanium dioxide	12.3					3.0						18			
Lithopone				10.0	20	52.0	34.3	27.6		40.0		32	60		
Lithopone, titanated									44.0						
Magnesium silicate	9.2	7			26	10.0	40.0	51.5	4.0	10.0	35.4	44			
Silica				18.3						10.0					
Barium sulfate				3.1					12.0						
Calcium carbonate	3.1												21		
China clay															
Total pigment	100.0	100	100.0	100.0	100	100.0	100.0	100.0	100.0	100.0	100.0	100	100		100
Liquid composed of															
Unbodied drying oils	88.5	86	89.0	87.0	83	85.0	85.0	59.9	86.0	90.0	67.5	} 58.6	} 58		79.0
Bodied drying oils								21.8							7.3
Resins								1.9				7.3			7.3
Turpentine and drier															
Mineral spirits, drier	11.5	14	11.0	11.0	17	15.0	15.0	[illegible]	14.0	10.0	29.0	34.3	22		10.0
Water				1.8				3.8			3.5		20		
Total liquid	100.0	100.0	100.0	100.0	100	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100		100.0
Volume analysis, in gallons[1]															
White lead (carbonate)	.071	.069	.027	.096										0.296	.107
White lead (sulfate)				.031	.042			.012							
Leaded zinc oxide (35%)	.068		.076			.077	.047								
Zinc oxide, lead-free		.046		.068	.048			.088	.079	.059	.065	.014			
Titanium-barium pigment		.112	.131								.064		.023		.169
Lead titanate															
Titanium dioxide	.040					.030						.021			
Lithopone				.033	.063	.157	.066	.060		.077		.050	.074		
Lithopone, titanated									.110						
Diluent allowance[2]	.104					.066			.099			.055			
Total opaque pigments	.236	.227	.234	.204	.153	.270	.113	.097	.236	.136	.107	.140	.097	.296	.276
Magnesium silicate	.041	.032			.111	.046	.158	.169	.016	.056	.102	.104			
Silica				.066						.042					
Barium sulfate				.010					.038						
Calcium carbonate	.015												.042		
China clay															
Total pigments	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.211	.189	.139	.296	.276
Unbodied drying oils	.652	.660	.676	.619	.591	.587	.598	[illegible]	.658	.656	.505	} .440	} .474	.678	.576
Bodied drying oils								.164							.065
Resins								.002				.049			.046
Total nonvolatile	.900	.879	.900	.899	.855	.877	.875	.778	.879	.914	.716	.678	.613	.954	.917
Turpentine and drier														.046	
Mineral spirits, drier	.100	.121	.100	.093	.145	.123	.125	.108	.121	.086	.260	.322	.227	.020	.083
Water				.008				.114			.024		.160		
Total paint	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Characteristics of paint															
Group[3]	TLZ	TLZ	TLZ	PLZ	PLZ	PTLZ	PLZ	PLZ	PTZ	PZ	TZ	PTZ	TP	L	TL(Z)
Zinc oxide in pigment[4]	22	16	23	30	18	18	13	8	37	23	21	8	0	0	0
White lead in pigment[4]	39	27	18	31	16	9	9	6	0	0	0	0	0	100	39
Opaque pigments in total pigment[4]	119	88	100	73	58	93	67	35	105	53	58	74	70	100	100
Total pigment in total nonvolatile[4]	28	29	25	31	31	33	32	34	28	28	29	28	23	27	30
Type and grade of paint															
Type No. (see table 2)	14	15	16	17	18	19	19	20	21	22	22	23	23	24	25
Grade	A	B	C	C	D	D	B	E	D	D	E	D	F	A	A

[1] The volume analysis is recorded in U.S. gallons. If the computations are made in the same way but using tables of bulking values in British units or in metric units the figures remain the same but the units are Imperial gallons or liters, respectively.

[2] The diluent allowance for very opaque pigments is counted in the total opaque pigment but is not counted in the total pigment.

[3] Key to symbols: L, white lead or lead titanate; Z, zinc oxide; T, titanium pigment; P, zinc sulfide pigment; $(LZ)_n$, lead and zinc paint containing transparent pigment.

[4] In percentage by weight.

Z M 30863 F

NPC 005507

Lead titanate	3.0
Titanium dioxide	2.6
Zinc sulfide	2.3
Lithopone, high strength (50 percent ZnS and $BaSO_4$)	.75
Lithopone, titanated (15 percent TiO_2)	.5
Lithopone, high strength (50 percent ZnS and talc)	.4

The diluent for very opaque pigments is counted in the subtotal for total opaque pigments only. The subtotal for total pigments includes only the opaque and transparent pigments actually present. If less transparent pigment than the allowable diluent for very opaque pigments is used the total opaque pigments may exceed the total pigments, which is the case in Paints 12, 14, 16 and 24 but not in Paints 21 and 27. The subtotal for total nonvolatile is, of course, the sum of the total pigments, unbodied and bodied drying oils, and resins. Paint driers contain a relatively small proportion of nonvolatile but inasmuch as the conventional paint formulas rarely report the nonvolatile part of the drier it seems best to count the drier entirely as volatile liquid for the present. The error involved is small and the procedure has already become customary in paint technology.

Under the volume analysis of each paint in Table 1 are given certain characteristics of the paint that lead to its assignment to one of the types listed in Table 2 and to its grading. The group of types is indicated by letter symbols representing the nature of the opaque white pigments, L standing for white lead or lead titanate, Z for zinc oxide, T for titanium pigment, and P for zinc sulfide pigment. Six groups may be recognized: (1) White lead and zinc oxide paints of the "100 percent pure" variety in which there is no transparent pigment, symbol LZ; (2) white lead and zinc oxide paints containing transparent pigments, symbol $(LZ)_n$; (3) titanium pigment, white lead, and zinc oxide paints, symbol TLZ; (4) zinc sulfide pigment, white lead, and zinc oxide paints with or without titanium pigment in addition, symbols PTLZ and PLZ, respectively; (5) lead-less paints, symbols TZ, PZ, PTZ, and in paints of very low grade P and PT; (6) zinc-less paints, symbols L and TL. The advertising claims under which the LZ paints appear in commerce make it necessary to recognize them as a group distinct from the $(LZ)_n$ paints; from the strictly technologic point of view alone one group would suffice for them both. For reasons already discussed the proportions by volume of zinc oxide and of white lead or lead titanate in the total pigment are considered important characteristics which, together with the group, determine the classification by type in Table 2. Valuable auxiliary information about the nature of the paint is offered by the percentage of opaque pigments in the total pigments by volume and the percentage of total pigments in the total nonvolatile by volume.

The last two lines of Table 1 indicate the type identification of the paint as listed in Table 2 and the grading of the paint. The assignment to grade depends upon the following rules:

Table 2.--Types of unbodied drying oil house paints found on the market and distribution of 102 commercial paints by type and grade

Reference No.*	Group	Range in content of zinc oxide	Range in content of white lead	A	B	C	D	E	F	All grades
				Number of commercial paints of grade indicated						
1	LZ	Very high, over 50	High, 36-50				2			2
2	LZ	High, 36-50	Very high, over 50			2				2
3	$(LZ)_n$	High, 36-50	High, 36-50		2	1				3
4	$(LZ)_n$	High, 36-50	Medium, 25-35					1		1
5	LZ; $(LZ)_n$	Medium, 25-35	Very high, over 50		3	3	1			7
6	$(LZ)_n$	Medium, 25-35	High, 36-50		2	5	1			8
7	$(LZ)_n$	Medium, 25-35	Very low, under 10					1		1
8	LZ; $(LZ)_n$	Low, 10-24	Very high, over 50		1	2				3
9	(LZ)	Low, 10-24	Low, 10-24					2		2
										25
10	TLZ	High, 36-50	Low, 10-24			1				1
11	TLZ	Medium, 25-35	High, 36-50	4	1	1				6
12	TLZ	Medium, 25-35	Medium, 25-35	1		1	1			3
13	TLZ	Medium, 25-35	Low, 10-24	4						4
14	TLZ	Low, 10-24	High, 36-50	1	1	1				3
15	TLZ	Low, 10-24	Medium, 25-35	1	3					4
16	TLZ	Low, 10-24	Low, 10-24		2	4	1			7
										28
17	PLZ	Medium, 25-35	Medium, 25-35			1				1
18	PLZ	Low, 10-24	Low, 10-24			3	4	2		9
19	PLZ	Low, 10-24	Very low, under 10	2	1	2	5	1		11
20	PLZ	Very low, under 10	Very low, under 10					3		3
										24
21	Lead-less	Medium, 25-35	None		1		2	1		4
22	Lead-less	Low, 10-24	None			2	4	3		9
23	Lead-less	Very low, under 10	None				1	1	4	6
										19
24	Zinc-less	None	Very high, over 50	1						1
25**	Zinc-less	None	High, 36-50	1						1
										2
										102

*The numbers are intended for cross reference to Table 1 only and are not to be permanently associated with the types.

**This type is moderately fortified with resin.

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Grade of paint	Minimum content of - Opaque pigments	Total pigments	Total nonvolatile
	In gallon per gallon of paint		
A	0.25	0.25	0.89
B	.21	.23	.82
C	.17	.21	.75
D	.13	.19	.67
E	.09	.17	.60
F	--	--	--

In applying these rules no paint is placed more than one grade below the grade to which it would be entitled by its opaque pigments unless both total pigments and total nonvolatile are below that grade, in which case it is placed two grades below. Paint No. 1, for example, with 0.183 gallon of opaque pigments, 0.183 gallon of total pigments, and 0.877 gallon of total nonvolatile, falls in grade C with respect to opaque pigments, E with respect to total pigments, and B with respect to nonvolatile and is therefore placed in grade D rather than grade E. Twenty-three of the 30 paints fall in the grade to which they would be assigned with respect to opaque pigments alone while the remaining 6 paints are placed one grade below because either the total pigments, total nonvolatile, or both fall in the lower grade.

Within each group of types the content of white lead and of zinc oxide in the total pigment varies very widely. This is particularly true of groups LZ and $(LZ)_n$. Subdivision of the groups into types is therefore necessary but, for the present at least, the subdivisions must be drawn arbitrarily. For white lead and zinc oxide separately five ranges in percentage of the total pigment by volume are set up as follows:

Very high range	over 50 percent
High range	36 to 50 percent
Medium range	25 to 35 percent
Low range	10 to 24 percent
Very low range	below 10 percent

A type of paint is defined by the group, range of zinc oxide, and range of white lead. With six groups and five ranges for zinc oxide and white lead more than 90 types of paint might be possible. (The combinations of 6, 5, and 5 are, of course, 150 but the facts that in LZ paints the lead and zinc pigments must total 100 and that one group contains no lead and another no zinc materially reduces the possible combinations.) Not all of the types theoretically possible are practicable. Apparently the paints now on the market represent not many more than 25 of the possible types.

Table 2 lists 25 types and indicates the distribution of 102 commercial prepared paints both by type and grade. Most of the nationally known brands and many brands of smaller manufacturers are included in the 102. It is probable, of course, that examination of a still larger number of commercial paints would reveal a few more types not listed in Table 2.

Application to Paste Paints and Enamelized Paints

The discussion so far has been confined to prepared paints. According to the traditional terminology of the industry prepared paints, when stirred to uniform suspension, are of suitable consistency for application as finish coats without any addition of liquids (18). Paste paints, on the other hand, are concentrates calling for considerable addition of linseed oil, thinner, and sometimes drier. Paste paints may be brought within the scope of the proposed system by calculating the volume analysis for the paint after it is thinned in accordance with the manufacturer's directions for finish coat. Paint No. 29 in Table 1 is a paste paint identified and graded in that way. A few prepared paints in recent years have appeared on the market in a consistency intermediate between that of paste paints and paint ready for application. Such paints might properly be called semiprepared paints but in any case the volume analysis should be calculated for the paint after thinning as directed for finish coat.

Inclusion of enamelized and quick-drying house paints would add materially to the number of types listed in Table 2. Even where the composition of the pigment falls within the range of one of the types there indicated a separate type should be recognized because of the differences both in the nature of the liquids and in the physical properties of the paints. In many cases, however, the change in the liquid necessitates significant changes in the pigments. Replacement of unbodied drying oil with bodied oil or varnish tends to alter consistency in such a way that the content of total pigment in the paint must be diminished, the proportion of opaque pigment in the total pigment increased, and the content of total nonvolatile in the paint diminished. Moreover, if bodied oil without resin is used in the vehicle to make enamelized paint the content of zinc oxide in the pigment is sometimes unusually high while if resin is used the zinc oxide content must often be closely restricted. Enamelized paints are rarely rated above grade C in the proposed system. If they become generally used for house painting it may be desirable to establish a separate set of grading rules for them, possibly by omitting the requirement of a minimum content of total pigments. The enamelized paints differ from true house paints in fundamental physical properties affecting their use (6) to such an extent that sharp differentiation from true paints is essential. The quick-drying paints, unless they are likewise enamelized, resemble the true paints more closely and call for no change in the proposed grading rules, though they must be recognized as separate types because they are not always compatible with ordinary house paints.

Symbols for Representing Paints

In the text of the five preceding paragraphs the latter symbols for the groups are used with obvious advantages for clarity and brevity of exposition. If the proposed program is adopted by the paint industry such symbols may prove convenient in identifying marks to indicate the types of paints to purchasers. One manufacturer, in fact, now uses the symbol LTZ on his "lead, titanium, and zinc" paint, though not as part of the trade mark. For such purposes the symbols must be very simple. Both LZ and $(LZ)_n$ groups would probably be written LZ and distinction made by calling the former "100 percent pure" just as is done commercially at the present time.

For use by technical men, however, the letter symbols may be elaborated to great advantage in keeping records and making reports. Paint No. 1 in Table 1, for example, is written LZ_{55}, p/nv 21, indicating that the pigment contains 55 percent zinc oxide by volume and that the total pigment is 21 percent of the total nonvolatile by volume. Since the pigment consists entirely of white lead and zinc oxide it is unnecessary to write the subscript 45 to symbol L. Paint No. 3 is written $(LZ_{40})_{84}$, p/nv 28, subscript 84 indicating that the white lead and zinc oxide together amount to 84 percent of the total pigment by volume; the white lead is therefore 44 percent. Paint No. 12 is written $(TL_{40}Z_{28})_{118}$, p/nv 28, subscript 118 indicating that the total opaque pigments exceed the total pigments because of the convention adopted for the very opaque pigments. Paint No. 30 is written TL_{39}(f), p/nv 30, the symbol (f) indicating that it is a resin-fortified paint. An enamelized paint made with bodied oil and no resin is written $(TZ_{67})_{186}$ (e), p/nv 19, which represents a product now on the market. For enamelized paints containing resin symbol (re) is used in place of (e) and for quick-drying paints (q).

Complexity of the Present Paint Market

Paints of the LZ and $(LZ)_n$ groups represent the old traditions of the mixed-pigment paint industry while the TLZ, PLZ, and lead-less groups are comparatively modern developments. The distribution of paints in Table 2 indicates that the older groups have by no means been pushed off the market by the newer ones. The LZ paints hold their place largely because, since the passage of the famous paint law in North Dakota, they can be advantageously offered under the slogan of "100 percent pure paint", all other paints except pure white lead paint being "impure" by reason of a content of transparent pigments. The $(LZ)_n$ paints retain an important place because they frequently represent the tinted paints in brands in which the white paint is of the TLZ group inasmuch as many manufacturers fear that tinted TLZ paints will be subject to too much complaint about fading of colors. Among the newer paints the industry clearly prefers the TLZ paints for high grade products and resorts to the cheaper PLZ and lead-less groups for paints of lower grade. This discrimination, however, is not necessarily technologic in its basis but may be due largely to prejudice against zinc sulfide pigments in outside paints. The early lithopone paints belonged to the lead-less group and contained very generous proportions of transparent pigments; their lack of success may have been caused more by the absence of white lead and their low grade than by the presence of lithopone. Absence of paints of grade A from the LZ and $(LZ)_n$ groups may be attributed partly to tradition but still more largely to cost, for such paints would be more expensive than TLZ paints of grade A.

At the present time the term first grade paint means little more in the industry than the most expensive paint of two or more brands offered by a single manufacturer. The "grades" of one manufacturer are not necessarily comparable with the "grades" of another manufacturer. Among the 102 paints of Table 2, manufacturers' first grade paints range from A to D in the proposed system of grades while manufacturers' second grade paints for the most part fall in grades C to E. Paints of grade F may safely be described as disreputable but no such term of opprobrium may safely be applied to paints of grade E.

There is no sound justification in technology for the large number of types and grades of house paint now on the market. The numbers result primarily from the lack of purposefulness in formulation and the absence of systematic classification of paints. If the proposed system of type identification and grading should be adopted by the paint industry many of the present types and grades could and undoubtedly would be abandoned, leaving only a number sufficient to meet the needs of varying conditions of exposure, maintenance programs, climatic conditions, and reasonable prejudices of users. With a limited number of types and grades of paint clearly identified in the trade an effective program of education of painters and paint users in correct methods of applying paints and safe methods of maintaining paint coatings becomes possible. Without some method of describing paints adequately painting and paint maintenance must remain far too intricately technical to be understood by laymen and continued multiplication of the kinds of paint on the market must inevitably increase the already appallingly large proportion of disastrously early paint failures. Since we can hardly expect to make technologists of painters and house owners we must find means of making paint simple enough for craftsmen and the public to use intelligently.

Simplified Description of Paints

If the system of type identification and grading herein proposed should be adopted by the industry, the present impracticably cumbersome formula label would give way to some such simple statement as the following:

"____________Brand Exterior House Paint
" Color - White
"Type - TLZ, low content of zinc oxide, medium content of white lead

"   Grade - A
"Type and grade according to standards of the
_______ Association."

The proposal is fundamentally similar to present practice in the sale of yard lumber, type identification of paint being analogous to species identification of lumber and grading of paint to grading of lumber.

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