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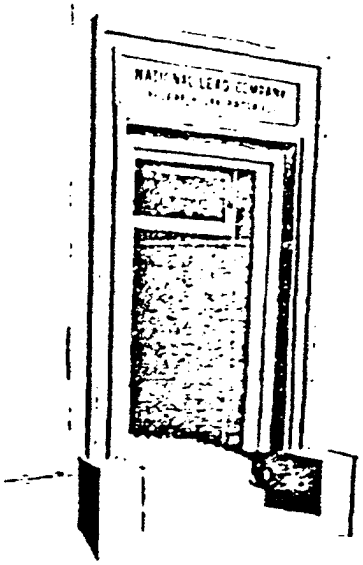
The "Dutch Boy"

BENTONE® HANDBOOK

for the

PAINT, PLASTICS, MASTIC COMPOUND and ADHESIVE INDUSTRIES



NATIONAL LEAD COMPANY

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TABLE OF CONTENTS

		Page
I	INTRODUCTION	3
II	GENERAL CHEMICAL AND PHYSICAL PROPERTIES OF BENTONE 34	4
	Table of Properties of BENTONE 34	5
III	THEORY OF THE ACTION OF BENTONE 34	6
	Manufacture of BENTONE	6
	Structure of Montmorillonite	6
	Conversion of Montmorillonite to BENTONE	8
	Effect of Ratio of Onium Salt to Montmorillonite	8
	BENTONE 34	8
	The Formation of a BENTONE Gel	9
	Characteristics of the BENTONE Gel	15
	Thixotropic Structure	15
	Bodying Agents	18
	Polymerized Oils	18
	Metallic Soap Gels	19
	BENTONE 34	19
	Concentration of BENTONE - versus - Continuity of Gel Structure	19
	Effect of BENTONE Gel on Complex Systems	20
	Complex Resin-Vehicle-Solvent Systems	20
	Vehicle-Pigment Systems	21
	Multiple Pigment Systems	22
	Solvent Release Characteristics	22
	Temperature Independence	24
	Limitations of BENTONE Gels	25
IV	FACTORS AFFECTING BENTONE 34 IN USE	26
	Mechanical Shear Action	26
	Pebble Mill	26
	Roller Mill	27
	Colloid Mill	27
	Stirring	27
	Masterbatching	28
	Thermal Effects	28
	Polarity of the System	28
	POLARITY CLASSIFICATION OF ORGANIC SYSTEMS AS A GUIDE FOR USE IN BENTONE GELATION	30
	Order of Addition of Polar Constituent	32
	Degelation	33
V	GENERAL ADVANTAGES OF BENTONE 34	35
	1. Improved Brushability	35
	2. Sag Prevention	35
	3. Improvements in Spraying and Dipping Applications	35
	4. Pigment Suspension Properties	36
	5. Bodying Action and Viscosity Control	36
	6. Temperature Independence of BENTONE Gels	36
	7. Package and Aging Stability	36
	8. Color Uniformity Through Penetration Control	36
	9. Color Uniformity Through Flooding Control	37
	10. Water Resistance	37
	11. Chemical Resistance	37
	12. Improved Structure Reinforcement	38
	13. Flatting Action in Clear Systems	38

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V GENERAL ADVANTAGES OF BENTONE 34 (Cont'd)
14. Effect of BENTONE 34 on Adhesion
15. Effect of BENTONE 34 on Solvent Release

VI SPECIFIC APPLICATIONS OF BENTONE 34 (GENERAL FORMULATIONS)
Paints
Exterior House Paints
Exterior Primers
Exterior Topcoats
Sash and Trim Paints
Interior House Paints
Wall Primer-Sealers
Interior Enamels
Interior Flats
Interior Flats of Low Solids Content
Stipple Paints
Metal Protective Paints
Rubber-Base Paints (Styrene-Butadiene and Chlorinated Rubber)
Asphalt Paints
Clear Finishes
Traffic Paints
Maintenance Paints
Stains
Furniture Stains
Shingle Stains
Shoe Stains
Mastic Compounds
Putty, Caulking Compounds and Wood Fillers
Non-Inflammable Paint and Varnish Removers
Printing Inks
Typographic Inks
Heat-Set Newsprint Ink
Other Heat-Set Typographic Inks
Water- or Steam-Set Typographic Inks
Lithographic Inks
Intaglio (Rotogravure) Inks
Vinyl Dispersions
Plastisols and Organosols
Plastigels
Wax Reinforcement
Synthetic Resin Adhesives
Other BENTONE Applications
Hydraulic Fluids
Drawing Compounds
Buffing and Cutting Compounds
Polyesters
Colors-In-Oil
Silk-Screen Printing Inks
Emulsion Systems
Latex Paints
Other Emulsion Systems

VII CONCLUSION

VIII MATERIALS AND MANUFACTURERS

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1 - INTRODUCTION

BENTONE is a registered trademark of the Baroid Division of the National Lead Company, applied to a class of products resulting from cation exchange reactions between organic bases and bentonite or its clay mineral component, montmorillonite, the individual products being identified by a number following the mark BENTONE. Throughout this Handbook, whenever the mark BENTONE is used, the designation refers specifically to one member of the class, BENTONE 34.

What happens essentially in the formation of these products is that sodium bentonite, plus an organic ammonium or onium salt, undergoes an equilibrium reaction to form an organic onium bentonite plus salt. Insolubility of the onium bentonite compound favors the reaction to the right.

The most versatile material is BENTONE 34, which is dimethyldioctadecyl ammonium bentonite. It will gel many single organic liquid systems such as aromatic hydrocarbons and various aliphatic liquids such as petroleum oils.

Building on foundation work laid by Dr. E. A. Hauser[1], researchers at Mellon Institute (under the fellowship of the Baroid Sales Division, National Lead Company) prepared a large number of compounds and studied their chemical, physical and rheological properties. After evaluation of manufacturing methods, a pilot plant was built at Mellon Institute. It provided materials for product development, and processing and equipment data were worked out for the design of a commercial plant.

Use research was split up between Mellon Institute and the Brooklyn Laboratories of the National Lead Company. Potential uses for the BENTONE in lubricating greases and paints were investigated.

Important properties of gelled systems containing BENTONE came to light. Among them: complete absence of melting at high temperatures; lack of phase changes at any temperature, including very low ones; resistance to action of water, due to freedom from hydrolysis and its by-products; and stability of gel structure on standing or under mechanical working[2].

The following pages of the "DUTCH BOY" BENTONE HANDBOOK contain a theoretical discussion of BENTONE 34 gels. This discussion is illustrated with gelation data showing the effect of various types of chemical additives to insure maximum and easy bodying of a considerable variety of industrial products. The information contained in the theoretical sections in the BENTONE HANDBOOK should prove of considerable value as an aid to formulators in the paint, plastics, adhesive and mastic compounds industries. Following the theoretical discussion, another large section of the Handbook is devoted to formulations demonstrating the use of BENTONE 34 in a great variety of industrial products.

[1] E. A. Hauser, U. S. Pat. No. [illegible], November 30, 1954.

[2] "Outlook of Bentonite Chemistry", Chem. Eng., 50, 1, [illegible] (1953). Reprinted, Courtesy McGraw-Hill Publ. Co.).

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II - GENERAL CHEMICAL AND PHYSICAL PROPERTIES OF BENTONE 34

BENTONE 34 is a finely divided, light cream-colored powder which ha the property of swelling in liquid organic systems. As previously explained, i is a reaction product of an organic ammonium cation with the inorganic min eral, montmorillonite.

Montmorillonite is the chief mineral constituent of bentonite, well know for its ability to swell in water. The chemical composition of montmorillonit is ideally $Al_2O_3.4SiO_2.2H_2O$ with isomorphous replacement of aluminum b other cations. The base-exchange reaction between an ammonium salt an montmorillonite results in the formation of an electrovalent linkage betwee the organic ammonium cation and the mineral.

The organic cations attached to the montmorillonite are the component of BENTONE 34 which render it organophilic, and thus capable of swelling an gelling in organic systems. The type of cation employed in making a BENTONE governs the organophilic character of the product. A large number of BEN- TONES have been made experimentally and studied thoroughly. The commer- cially available BENTONE which has found wide industrial application i BENTONE 34.

BENTONE 34 effectively gels a wide variety of organic liquids. It oper ates best in solvents of low and intermediate polarity. A thorough discussio of polarity and other factors affecting BENTONE 34 in use will be found i Section IV.

BENTONE 34 is chemically neutral, and does not react with the norma organic systems in which it swells. There is no free amine present in th BENTONE, nor is it extracted by any common organic solvents. It is als resistant to the action of dilute inorganic acids and alkalis. However, pro longed contact with strong acids and alkalis may cause decomposition of th BENTONE with consequent reduction of gel strength.

Because each ultimate particle is coated with a long chain paraffin hydro carbon structure, dry BENTONE 34 is not easily wetted by water. This is definite advantage when BENTONE 34 is incorporated in organic coatings, sinc it increases the natural water repellency of the system. On the other hand BENTONE 34 is an excellent emulsifier for water in oil emulsions. Work no under way also indicates that once BENTONE 34 has been incorporated in a emulsion, it contributes valuable properties to dispersions of organic system in water.

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TABLE OF PROPERTIES OF BENTONE 34

COMPOSITION	Dimethyldioctadecyl ammonium bentonite
SPECIFIC GRAVITY	1.80
BULKING VALUE	15.0 lbs./gal.
COLOR	Very light cream
ULTIMATE PARTICLE SIZE*	Platelets: 0.05-1.0 micron by 0.002-0.004 micron thick
FINENESS	Less than 5% on 200 mesh sieve
WATER CONTENT	Less than 3.0%

* When properly dispersed as discussed in Sections III & IV.

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III - THEORY OF THE ACTION OF BENTONE 34

Manufacture of BENTONE

The replacement of the surface cations on the montmorillonite plat ts by organic cations is the basis of the preparation of BENTONES. Montmo: l-onite is dispersed in water and treated for the removal of impurities. A s t-able organic base is then added in the form of its salt. The flocculated proc t is washed, filtered, dried, ground and packaged.

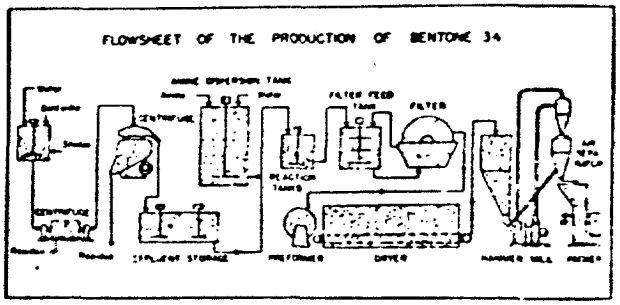

Figure I[3]

FLOWSHEET OF THE PRODUCTION OF BENTONE 34

Structure of Montmorillonite

The special characteristics of the mineral montmorillonite are impor tant in the functioning of a BENTONE. Montmorillonite is a hydrous substi tuted aluminum silicate, with a micaceous structure and an exceptionally smal ultimate particle size. It is noted for its ability to swell in water. Varyin proportions of calcium, magnesium, and sodium are found in the cation ex-change positions of montmorillonite, depending upon the source of the material. The fundamental structure is considered to be as shown in Figure II.

[3] "Output of Bentonite Clinics", Chem. Eng., 10, 1, [illegible]. (Courtesy McGraw-Hill Publ. Co.)

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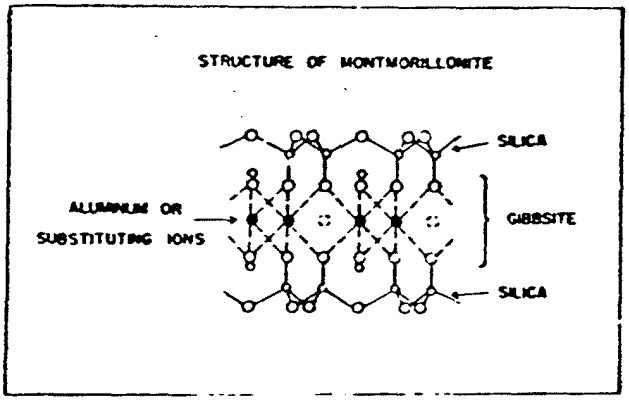

Figure 8[9]

STRUCTURE OF MONTMORILLONITE

A sheet of gibbsite, $Al_2O_3.2H_2O$, is sandwiched between two layers of tetrahedral silica. During the process of formation, under suitable conditions, divalent cations are substituted to varying extents for aluminum ions in the ideal lattice. This isomorphic substitution gives rise to charges in the structure capable of holding cations on the surface of the platelet, and in properly selected samples of montmorillonite, a high proportion of the surface cations are sodium ions. It has been shown[1] that about 80% of the total exchange positions are on the basal plane surfaces with the remainder on the edges of the platelets. With this assumption, it can be calculated that montmorillonite, with a base-exchange capacity of one milliequivalent per gram, has an average area per base-exchange position of 165 Å.[2] This is further supported by the fact the base-exchange capacity is virtually independent of particle *size*.[3] The thickness of a platelet is 9.6 Å or approximately one millimicron. The other two dimensions are of the order of 150 Å, so that the ultimate particle is a sheet or platelet of very small size.

[1] [illegible]

[2] [illegible]

[3] [illegible]

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Conversion of Montmorillonite to BENTONE

When a platelet of montmorillonite is coated with hydrocarbon-amin chains by base-exchange, the major significance of the alteration is the immed ate reduction of hydrophilic character. This occurs for two reasons:

1. The base-exchangeable cations which hydrated very strongly have been removed, and replaced by nitrogen-hydrocarbon configuratio which do not hydrate.
2. A large portion or all of the mineral surface, which formerly adsorb water, has been coated with hydrocarbon chains.

An electrovalent bond is formed between the nitrogen atom of the organic am monium cation and the montmorillonite structure. In addition, the hydrocarb chains are held firmly to the surface of the platelet, along their entire leng by attractive forces. Our interpretation is that these chains are held fl against the surface in the dry BENTONE before gelation, and this is support by basal plane spacing studies.[7]

Effect of Ratio of the Onium Salt to Montmorillonite

The gelling ability of a BENTONE is materially affected by the ratio ammonium salt to clay mineral.[7] Studies, using from 50% to 200% of the amin salt equivalent to normal exchange capacity, show that optimum gelling abili is obtained in the region of 100% equivalence. There is a regular decrease gel strength on either side as the ammonium salt: clay mineral ratio diverg farther from the optimum. It is interesting to note that substantial retenti of amine can be obtained at higher ratios of amine to mineral than the norm exchange equivalent. This is assumed to be due to physical adsorption of th excess amine on the mineral surface. An increased separation of platelets obtained, which appears to be the result of crowding of amine chains, but th gelling capacity falls off. This effect has been explained as the saturation the adsorptive forces of the mineral surface by the free amine. Since gel for mation is believed to depend upon adsorption of the liquid medium on the plate let surface, the coating of the free amine interferes with initial adsorption an subsequent solvation by the liquid medium.

It is readily understandable that lower amine ratios would result in poorer gelling power. The montmorillonite surface with incomplete amine coating is less organophilic and relatively less compatible with an organic gelling medium

BENTONE 34

At about 100% equivalence, the size of the organic ammonium cati governs the extent to which the surface of the platelets is covered. BENTON

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34 is a dimethyldioctadecyl ammonium salt of montmorillonite. With an ion of this size, complete reaction results in 140% coverage.

Figure III is a diagrammatic edge-view of BENTONE 34*. X-ray data shows that in BENTONE 34 the normal separation of the platelets is approximately 9 Å, as indicated in the diagram, due to the overlapping of the amine chains.

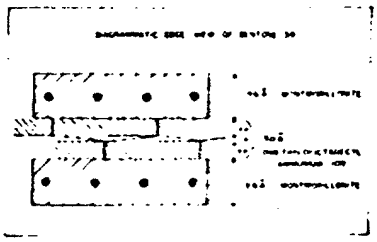

Figure III
DIAGRAMMATIC EDGE-VIEW OF BENTONE 34

The separation of platelets in BENTONE 34, due to the chain crowding shown in Figure III, is advantageous in the subsequent formation of a gel. Easier access is permitted to the chain and to the active surface of the platelet by organic solvent and polar constituent.

The Formation of a BENTONE Gel.

The organic portion of a BENTONE enables it to form gels in organic solvents. The solvation energy of the organic medium for the amine chains is the most important single factor in the gelation of BENTONE 34. Since such energies are of a low order of magnitude, however, direct and spontaneous gelation in a hydrocarbon solvent does not occur readily. If the solvent has some polarity, or the proper combination of polar and non-polar solvents is used, reasonably good direct gelation may be obtained. Yet the solvent combination required may not be the optimum one in terms of simply being the best hydrocarbon chain-solvating agent. This is a basic point of great importance. The forces holding the hydrocarbon chains on the surface of the platelet must be preferentially satisfied in some way, at least temporarily, in order for

*[illegible]

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solvation of the chains to occur. A second reason for satisfying the rema ng attractive forces of the platelet, is that strong attraction still exists u he BENTONE between adjacent platelets, and this must be overcome in obta ng chain solvation and gel formation. The activity of polar solvents in BENT(?Z gelation is readily accounted for on this basis.

When BENTONE 34 is added to a non-polar liquid, and a polar liqu is added to form a gel, it is found that optimum gel strengths are obtain d approximately 30% of methanol, 45-60% of ethanol (95%), and about 60 of acetone, based on the weight of the BENTONE 34. In general, as the chain le th of the alcohol increases, the optimum gel strengths become progressi ly weaker. There is a reasonably good linear relationship between the amou t of alcohol required and its molecular weight. The mole fraction of each alc ol required for optimum gelation is generally constant in the series, sugges g that the common hydroxyl group is the key factor involved in the gelat n. Similar studies with other polar solvents, such as esters and ketones, dem n strate good correlation between activity and molecular weight. Mac Ew n[1] has shown that the molar heat of adsorption of methanol on montmorillonit is approximately 11.5 kcal. per mole. This corresponds to about 80% of the t of formation of a BENTONE."

The adsorption of an organic compound on montmorillonite is contro l by the size of the molecule and its polarity, and the relative activity of th e materials in promoting BENTONE gelation follows the same general rule. n a series of mono-substituted benzene solvents, there is a progressive incre e in maximum gelation with BENTONE 34 as the substituted group increase s electron-attracting power. This reaches a maximum with nitrobenzene, a s minimum in alkyl substituted benzenes, for this series. The agreement n the generally accepted order of orientation-directing power in aromatic s stitutions is surprisingly good. Strong meta-directing groups produce greatest gelling power, followed by weaker meta-directors, and then the co mon ortho-para directing groups.

Toluene is adsorbed by montmorillonite much more readily than sat ated aliphatic hydrocarbons[2], and it is found in practice that BENTONE gels much more readily in toluene alone than in aliphatic hydrocarbons alo

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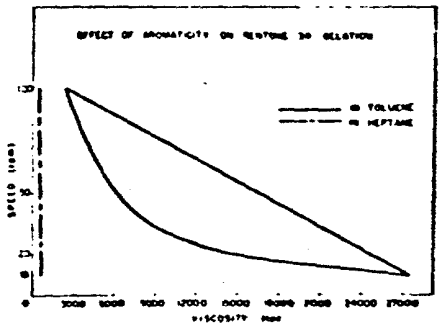

Figure IV

EFFECT OF AROMATICITY ON BENTONE 34 GELATION

Figure IV illustrates the difference between toluene and n-heptane as gelling agents for BENTONE 34. These curves were obtained by pebble milling 7.5% of BENTONE 34 in each solvent for 24 hours, and then measuring their consistencies with a Brookfield Viscosimeter. The much greater gelation in toluene is apparent. Although the use of the Brookfield instrument in studying flow properties is theoretically far from perfect, a reasonable indication of the thixotropic nature of a system is inferred from the amount of curvature at different shear rates.

As a reference point, a Newtonian liquid gives a vertical straight line under these conditions. A plastic system gives a straight line with a degree of slope which is characteristic of the individual system. A dilatant system would give curvature which is a reverse of that in Figure IV, showing increasing apparent viscosity at higher rates of shear. Actually, a pseudoplastic system could give curvature which is the same as that for thixotropy on this instrument. This is true because thixotropy is defined by a measurable difference in recovery on standing, which is not measured property by the usual Brookfield method. For the sake of simplicity in this Handbook, we are describing these curves as thixotropic, realizing that pseudoplastic effects may be present, but that they do not alter the conclusions arrived at regarding the end-uses of the BENTONE. Figure IV demonstrates effectively that until gelation of the BENTONE occurs, the thixotropic properties of a BENTONE

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dispersion are not developed. Many other cases could be cited, such as the relative activity of aliphatic alcohols previously mentioned.

The general principle holds that two factors must be present:

1. Some part of the system must be readily adsorbable by the mineral platelet surface, with enough adsorptive force to release the hydrocarbon chains for solvation.
2. Solvation of the hydrocarbon chains must be reasonably good.

In Figure IV, toluene forms an effective gel because it meets both of these requirements. N-heptane meets the second requirement, since it solvates hydrocarbon chains without difficulty. It fails to gel BENTONE 34 when used alone, however, because it does not meet the first requirement, and does not make the hydrocarbon chain available for solvation. If the first requirement is met with the use of the proper amount of polar solvent, n-heptane will gel BENTONE 34 so effectively that its curve will practically superimpose on the toluene curve in Figure IV.

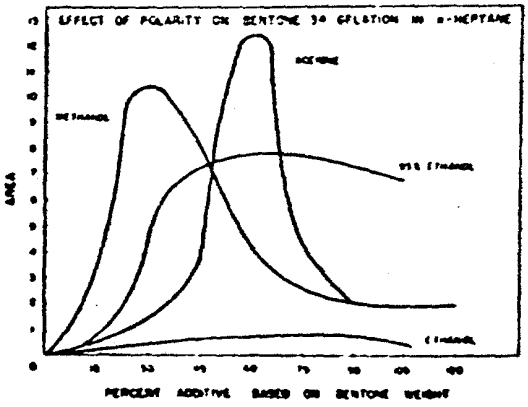

Figure V

EFFECT OF POLARITY ON BENTONE 34 GELATION IN N-HEPTANE

The effect of several polar solvents on the gelation of BENTONE 34 in n-heptane is shown in Figure V. In this figure, the area bounded by

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Brookfield curve in each case is plotted against the concentration of polar additive. Thus, each curve represents a number of determinations at different levels of polar additive.

It is apparent that methanol is by far the most active of the alcohols. Maximum effectiveness in this system is found at 30% methanol, based on the weight of the BENTONE. The difference between 95% ethanol and pure ethanol emphasizes the effect of polarity sharply. The high polarity of water is shown to be quite effective when a suitable coupling solvent is present. The very sharp peak in the acetone curve shows that, in practical use, acetone must be handled carefully. In contrast, the high plateau of the 95% ethanol curve shows that a good factor of safety exists for its industrial use, although its gel strength is not quite as high as the optima for methanol and acetone. The 30% methanol and 60% acetone maximum points are interesting in that these amounts represent almost exactly the same molar concentration of these two materials.

Figure V shows that acetone, methanol, and 95% ethanol are the most effective additives for BENTONE gel formation in extremely non-polar systems which are normally difficult to gel, as for example, the modern paints and other pigmented systems based on odorless mineral spirits. The optimum amounts of these additives are strongly adsorbed on the platelets, and present no odor problem.

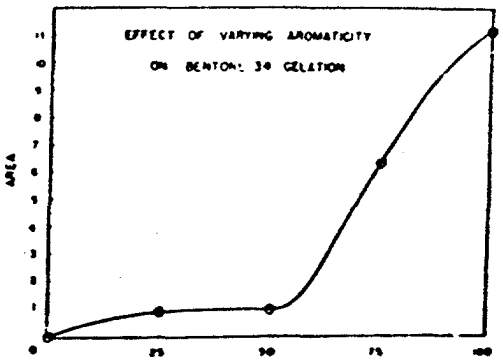

Figure VI

EFFECT OF VARYING AROMATICITY ON BENTONE 34 GELATION

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Figure VI shows the effect of varying aromaticity on the gelation of BENTONE 34. Mixtures of n-heptane and toluene have been used to illustrate the range of aromaticity prevalent in a variety of thinners and other petroleum derivatives. Figure VII shows the results obtained by adding polar solvent to each of these mixtures. The higher maximum points on the curves and the lower requirement of polar solvent, as aromaticity increases, are in general agreement with the foregoing discussion. The experimental results show some variations from the expected order, which was apparently due to changes in dispersion in those mixtures which tended to gel in the pebble mill.

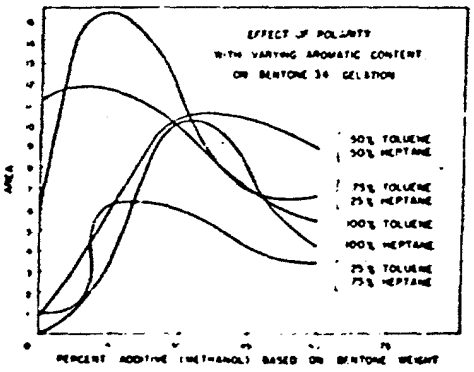

Figure VII

EFFECT OF POLARITY WITH VARYING AROMATIC CONTENT ON BENTONE 34 GELATION

Ideally, it should be possible to gel BENTONE 34, which is completely clad by hydrocarbon chains, to the maximum point in any organic system which would solvate the chains. If enough energy were put into the system, the platelets could be forced apart, followed by solvation of chains and adsorption of the organic medium on the then uncoated portion of the platelet surface. The stability of the gel formed would depend upon the energy of adsorption of the medium, since competition by way of desorption and inter-platelet attraction might occur. Polar solvent in small amounts is a practical way of satisfying the attractive forces and lowering the required energy input. Without polar solvent

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or with less polarity, it is possible to reach the desired end by increasing energy input to overcome the barrier of plate attraction. This can be done through mechanical energy, such as work on the system by milling, or in many cases by heat. Sometimes a combination of the two is most useful. The application of these methods in a practical way will be discussed in detail in Section IV.

Thus, the successful formation of a BENTONE 34 gel depends on the proper balance of polarity plus energy input. The nature of each organic system to be gelled is the governing factor. If no polar effect is contributed by the system, a fixed amount of polar solvent is adequate if the BENTONE is properly dispersed. The amount of added polar solvent required is determined by the number and type of polar groups and its molecular weight.

In the applications of BENTONE 34 for practical industrial purposes, it must be kept in mind that maximum gelation is highly important in the development of the desirable properties which the BENTONE is capable of imparting. Added to this is the obvious advantage of more efficiency, and therefore, the use of a minimum amount of BENTONE to do the given job.

Characteristics of the BENTONE Gel

Thixotropic Structure

The notable aspect of thixotropy is characteristic of a BENTONE-organic solvent gel. A 10% BENTONE 34 gel in toluene is a smooth, homogeneous, light colored gel. When agitated, the system liquifies readily to a fluid suspension of relatively low viscosity, and then reforms to a gel reversibly on standing. A reasonable measure of this effect is illustrated by plotting the readings taken at four different rates of shear with a Brookfield Viscosimeter (See Figure VIII).

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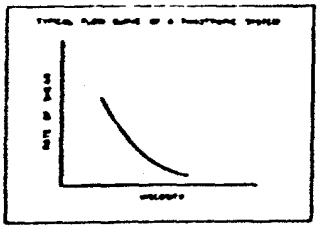

Figure VIII

TYPICAL FLOW CURVE OF A THIXOTROPIC SYSTEM

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As the shear rate increases, the apparent viscosity drops progressively lowe . When the shearing force is removed, the gel body of the system builds up agai . The usefulness of this flow property in industrial applications is obvious. Wher - ever it is desirable to make an organic solvent or vehicle resistant to flow f its own accord, and yet no harder to work than the original ungelled syster , the addition of the BENTONE increases the thixotropic flow properties in a very satisfactory manner.

We may visualize or interpret the thixotropic structure of BENTONE- organic gels as follows: The active ultimate unit is the platelet, which is n w surrounded by a comparatively large "envelope" of vehicle-hydrocarbon ch in solvate. Effective continuous gel structure is based on a bundle of such en- veloped platelets, which are still held in adjacent parallel oriented fashion by residual attractive forces in the mineral platelets. These gel bundles act by association with each other, and are believed to dissociate to a certain exte t under shear, then reassociate when the shear force is removed and the syst m is at rest.

From the practical standpoint of what BENTONE 34 contributes to the flow properties of a given system, the method of measurement is very importan . It is well known today, for example, that a single-point measurement, such as a paint consistency taken with one speed of stirring on a Stormer Viscosimet r, does not adequately define the flow characteristics of the paint.

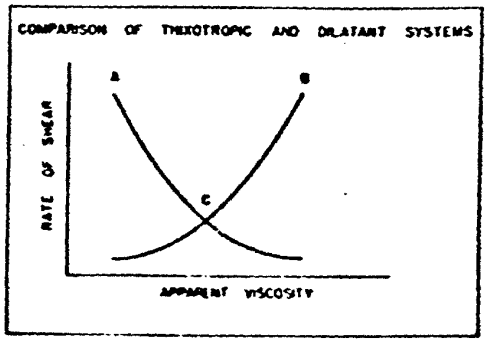

Figure IX
COMPARISON OF THIXOTROPIC AND DILATANT SYSTEMS

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An extreme case is shown in Figure IX to illustrate the point. Curve A represents a structure which breaks down under shear, i.e. either thixotropic or pseudoplastic. Curve B is typical of a dilatant structure, one which exhibits progressively greater resistance to shear force as the rate of shear is increased. If a single-point consistency measurement were taken at point C, the two completely dissimilar systems would provide identical readings, even though their performances in either high shear ranges (brushing, spraying, etc.) or low shear ranges (sagging, runoff after dipping, etc.) would be complete opposites. The application of curve measurements, taken under systematically varied rates of shear rather than single-point measurements, has proven enormously helpful in studying the performance of paints, inks, and other pigmented systems.

Paints, for example, have rather definite limits within which their flow characteristics must fall for a given purpose. They must flow readily and smoothly under the action of the brush, and then after application must level out under the surface tension of the vehicle so as to prevent brush marks and other non-uniformities. They must not run down on inclined surfaces or sag off the underside of horizontal ones. This combination of properties can be obtained only in a system which has a yield point high enough to prevent sagging or running and at the same time has a marked degree of thixotropy, readily becoming fluid under the action of the brush, then "setting up" after brushing is completed.

The use of sufficiently high pigment concentrations in paints has been the classical means of achieving the desired combination of flow properties. At low concentrations, the viscosity of a suspension of pigment in an oily vehicle is established by the size and mass of the liquid films separating the solid particles, and this in turn depends on the particle size, shape, and uniformity of shape of the pigment. At higher concentrations, the interaction of the dispersed particles alters the flow of liquid associated with the particles, and the plastic viscosity of the system is usually found to increase logarithmically with increasing pigment concentration. Many pigment-vehicle suspensions exhibit thixotropic flow properties at high pigment concentrations. Flat paints in general are good illustrative examples. Other ways of controlling the flow properties of a paint include many variations in vehicles, the addition of gelled structures, and balancing the type and amount of pigment.

Figure X shows measurements on three different semi-gloss enamels, using the Brookfield Viscosimeter.

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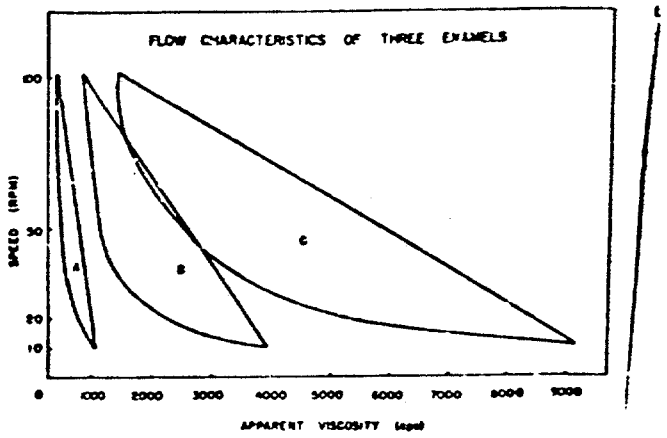

Figure X

FLOW CHARACTERISTICS OF THREE ENAMELS

Enamel A is too thin and too low in thixotropy, and in practical tes[illegible] sagged and ran excessively. Enamel C, on the other hand, did not sag or [illegible], but leveled poorly, showing excessive brush marks. The intermediate p[illegible] B was found to have the proper balance of good brushing and leveling, wi[illegible] sagging. The relative areas covered by these curves correlate well with [illegible] actual performance of the paints. Single-point measurements would fall [illegible]tirely short as guides to the actual flow properties in the cases illustra[illegible]

BODYING AGENTS

Polymerized Oils

When a gel structure of some type is added to a pigmented system, [illegible] as a paint, the effect on flow properties is usually additive if there is no ch[illegible]ical interaction. The addition of polymerized oil, or similar polymer, te[illegible] to increase the viscosity of a system. This type of modifier is usually a cr[illegible]linked or three-dimensional structure which holds a considerable amou[illegible] thinner or liquid vehicle in the structure of the gel. The result of hol[illegible]

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thinner in such a structure is a reduced evapo ion rate or slower solvent release. While certain of these gels show thixotropic flow properties, they usually have mixed effects in which pseudoplastic or dilatant structures are equally important. Their action is so mixed that the entire system has to be adjusted to reestablish the desired balance. The stability of polymerized oil additives on aging is usually poor, due to their tendency to polymerize further or to react with pigments or other vehicle components.

Metallic Soap Gels

Another common method of increasing viscosity employs metallic soaps. Gels of metallic salts of fatty acids are formed in organic solvents by heating, and they resemble the gelled vehicles described above. The soap gels vary considerably according to the chain length of the fatty acid and amount of free acid present, and in particular their strength and stability are critical with respect to the heat history of the system. Heat usually increases the gel strength up to a maximum point; then additional heat usually causes a marked decrease of gel strength.

The flow characteristics of a typical soap gel are mixed. A substantial amount of dilatancy is usually present, which accounts for the viscosity increase in an organic system when measured by an instrument which reflects the resistance to shear at a single point instead of a curve. The fact that an increased tendency to sag exists, which is not shown in this determination, is sometimes misleading. Nevertheless there is a variable proportion of thixotropy in most soap-type gels, and in the past, the use of metallic soaps has been a highly necessary adjunct in compounding pigmented organic systems to specific properties.

BENTONE 34

BENTONE 34 offers an entirely different approach in controlling flow characteristics, since any change it imparts is completely in the direction of adding thixotropy without introducing dilatancy. When properly gelled, it is not sensitive to the heat history of the system and does not affect the chemical reactions involved in film formation, or the adhesion of a film to a coated surface. In summary, BENTONE 34 is inert for all practical purposes, and it confers purely thixotropic gel structure to organic systems.

Concentration of BENTONE - versus - Continuity of Gel Structure

There is a definite relationship between the concentration of BENTONE in an organic system and the continuity of its gel structure. It seems evident that there must be enough gelled BENTONE particles present to reach a certain

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minimum average distance between particles, allowing them to interact by physical attractive forces. This can be visualized readily in the case of "b ing" an organic thickener. Actually there is always a critical concentrati in any complex system, below which BENTONE gels will give pigment suspen and sag resistance characteristics, and yet impart no measurable increas in the viscosity of the system. In typical paints, this critical point is usu lly around two to three pounds of BENTONE 34 per one hundred gallons of p t. This is a lower concentration of BENTONE than would be necessary for a c ntinuous gel structure in a pure solvent. The presence of other gelled structures (vehicle) provides a framework, materially reducing the mobility of the BENTONE gel particles, and providing a large number of attraction points for reinforcing the gel structure.

An interesting way of checking this "critical concentration" is to determine how much BENTONE is necessary in a simple system to give a non-bleeding heavy gel. In ordinary aromatic solvents it is found that about 4 % of properly gelled BENTONE 34 gives a continuous, non-bleeding system. Below this amount, some separation of gel and pure solvent may occur, even though some time may be required for it to happen.

Effect of BENTONE Gel on Complex Systems

Complex Resin-Vehicle-Solvent Systems

It has been pointed out that a vehicle gel structure can lower the m imum amount of BENTONE required for gel continuity, by providing a net or framework upon which the BENTONE gel can "build". This leads to on of the most interesting features of BENTONE gels. The hydrocarbon chain of the BENTONE form solvates with a wide range of organic systems, f m aliphatic thinners to aromatics, to polar solvents such as alcohols and keto s, and to esters. Even high molecular weight esters, such as polymerized dr ng oils, alkyds, and other vehicles, can be gelled separately. When BENTON is present and properly dispersed, there is no preferential gelled state n well-blended mixture of compatible organic components. This is readily il r trated. If a solution of polymerized linseed oil in benzene is gelled with B TONE 34, the system is homogeneous and remains so indefinitely. If the ge mass is allowed to stand open to the air, the benzene will evaporate at practi lly the same rate as from the ungelled mixture with the oil. If the majorit of the benzene is allowed to evaporate, the gelled structure remains without a structure at any stage of the evaporation. Actually it continues to exist when the oil dries to a hard film, as shown by the film reinforcement and of shrinkage of the film. It is an obvious conclusion that in a complex sys m the BENTONE gel exists continuously in equilibrium with the various compon

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of the system, and always holds a substantially quantitative mixture in the hydrocarbon chain-solvate gel structure. It is postulated reasonably that there is free movement in and out of the solvated gel, since the gel continues to exist during the changes of the quantitative balance in the system. This tendency to "couple" several phases of a complex system is a tremendous factor in improving its long-term storage, and it is the key to the proven practical ability of BENTONE to increase the storage life of complex systems, in the package, several-fold. It is not necessary to elaborate upon the importance of preventing phase separation, and combatting effectively the tendency of molecules to agglomerate and perhaps react chemically as a result of their proximity.

Vehicle-Pigment Systems

The role of pigment wetting in a typical organic system is closely allied to the "coupling" property. The wetting of a pigment by the vehicle is essential to proper dispersion. The adsorption of at least a mono-molecular layer of vehicle results in the satisfying of attractive forces in the pigment particle which would otherwise tend to be satisfied through agglomeration with other particles. In practically all commercial pigmented systems, the problem of settling would be minimized if agglomeration due to poor pigment wetting could be prevented, and if some agent could be added which would effectively and permanently keep the dispersed particles from settling to a hard cake. According to Stokes' law, the variables governing rate of settling are diameter of the particle, viscosity of the medium, and the difference between the specific gravities of the two. One approach in minimizing settling is to increase the viscosity of the medium. This is one of the reasons why a highly thixotropic point is desirable. Unfortunately there are practical limitations which restrict the extent to which the viscosity can be increased.

Since the relative specific gravities are fixed for any given pigment-vehicle combination, preventing agglomeration from increasing the effective particle diameter of the pigment in suspension is especially important. This is where the action of the BENTONE gel is of great advantage. The organic portion of the vehicle which is adsorbed on the pigment is oriented, with polar groups at the solid surface and non-polar fragments extending out and away from the particle. These organic chains or rings are solvated in such a way that they are included in the BENTONE gel structure together with other materials in the system, such as thinner and free vehicle. The coupling action of the gel thus results in a much larger effective coating or envelope of vehicle around each pigment particle, reducing the rate of settling and actually preventing hard agglomeration of particles which finally do settle.

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An interesting question arises as to whether or not BENTONE 34 affect actual soap formation through surface reaction with the pigment. The genera picture of normal behavior in a large number of paint systems leads us to infe- that BENTONE gels do not affect soap formation in any way. At any rate, th- coupling action described above will be operative with the non-polar portion o the acid chain after a soap has formed.

Multiple Pigment Systems

Another common problem encountered in pigmented systems is flooding. This behavior usually shows up in paints formulated with two or more pigment which frequently dry to a different color from that of the paint in the wet state. The differential separation of pigments, which is responsible for this, alter the hue of the dry film because one of the pigments concentrates at the surface of the paint.

Flooding is not limited to any specific pigment combination. Difference in particle size are important. In the process of evaporation, finer particle are often carried to the surface of a wet film by the streaming action resulting from the movement of solvent from the body of the paint film towards the surface. Large differences in specific gravity, and the relative extent to which they are wetted, are factors to be considered in mixtures of pigments. The viscosity of the system is quite important, and where it can be kept high enough flooding is minimized. BENTONE gels have been found to be very useful in reducing the tendency to flood. The same general principles explained above in connection with suspension of pigments also apply here. The inclusion of solvated particle-coating material in the BENTONE gel structure promotes the maintenance of a homogeneous system even as solvent evaporates. As solvent leaves the wet film it is continuously replaced by more free vehicle in the gel structure, and the mobility of the pigment particles is reduced greatly by the impeding gel structure surrounding them. The practical benefits in color uniformity control for interior flat wall paints, as described in more detail in Section V, is an excellent example.

Solvent Release Characteristics

Examination of the general physical properties of gel structures has usually given support to the theory that a network of micelle structures exists. Most of the work reported in the literature has been based on soap gels. In the familiar case of sodium oleate in water, colloidal micelles consisting of hydrated particles of the soap are present. These micelles hold substantial amounts of water in layers around the sodium atoms, through polar attractive forces. Even more water is probably confined in void areas which exist

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the network formed by a three-dimensional aggregation of these hydrated micelles.

The same situation is believed to exist in the case of a gel formed by the action of a metallic soap in an organic solvent. In this case, solvation of the hydrocarbon chains is the operating factor rather than water solvation of a metallic atom. Micelle formation is based on multi-layer chain solvation and the orientation of the soap molecules, and a similar three-dimensional network is built up which holds solvent in excess.

The evaporation rate of a volatile thinner which has been gelled with a metallic soap is greatly retarded in comparison with its rate of evaporation in the non-gelled state. The formation of the gel usually requires substantial input of energy, in order to solvate the chains and disperse the soap particles. Desolvation is slow and difficult. There is little, if any, spontaneous tendency of the soap molecules to reaggregate and liberate solvent, so that the desolvation process receives no help from this quarter. Added to the entrapment of solvent in voids in the gel network, the tangling and curling of the organic chains, resulting from the absence of forces or structures which might preserve some sort of regular alignment, trap larger than normal amounts of solvent in the resulting heterogeneous gel system. These factors appear to support logically the observed retention of larger than normal amounts of volatile solvents in such systems. These factors are equally important in explaining the same behavior in cross-linked gelling structures, such as polymers, bodied oils, etc.

BENTONE gels show an interesting contrast in their behavior to the ordinary type of three dimensional organic gels. BENTONE gels have little or no effect on solvent release. A thinner evaporates at almost the same rate from a BENTONE gel as it does in the free or ungelled state. The explanation is not actually known from rigorous proof, but the facts are in accord with the general theory of BENTONE gel structure which follows:

> At all times the hydrocarbon chains, attached to the montmorillonite platelet through nitrogen atoms, are held in a regular evenly-spaced pattern. They extend from the platelet in two general dimensions rather than three, since the edges of the platelets are so thin, that they may be discounted in terms of base-exchange area.

The picture of how a BENTONE gel forms, as explained in detail earlier, leaves no room for cross-linking other than a loose association of gelled "stacks" or bundles of platelets, with no solvent excepting a monomolecular layer trapped strongly in the network. In the individual bundle, solvent can easily be released

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because it is readily replaced by non-volatile vehicles or resins, as discussed previously. If no replacing organic medium is present in the system, release is still accomplished easily due to the attraction of the platelet surface for the amine-hydrocarbon chain. When solvent is released, chain entanglement is minimized by the regular spacing of the amine-hydrocarbon chains, aided by the fixed structure of the platelet.

The advantage of BENTONE gels, in increasing viscosity without retarding solvent release, is obvious in coatings of all types. The control of penetration becomes independent of the rate of drying, which widens the scope for the formulator tremendously.

Temperature Independence

The unusual nature of a BENTONE gel, as discussed in connection with solvent release, is evident in other ways. The viscosity of toluene gelled with BENTONE 34 changes very little with change in temperature. Many practical demonstrations have been given, but perhaps the most striking one is a comparison of cup greases made from a common lube oil stock. Cones of grease made from lube oils gelled with BENTONE 34 do not deform upon heating even up to the fire point, whereas the same oils bodied with other gelling agents thin out and run at the same elevated temperatures.

The interpretation of BENTONE gel structure, discussed in the section on solvent release, is in accord with the temperature independence of BENTONE gels. The organic medium is quite mobile throughout the gel structure, and can be pictured as moving freely in and out of the platelet-solvated chain structure. The gel acts as if it were essentially linear or two-dimensional, with only slight cross-linking between bundles through van der Waals' forces. Forces of association, such as van der Waal's forces, characteristically increase at lower temperatures and decrease at elevated temperatures. This is a major factor in viscosity change with change in temperature in any liquid. A cold liquid is more viscous than a hot one because its molecules are associated to a greater extent. Similarly, any gel structure depending on the van der Waals' association type of forces is sensitive to temperature changes. The unique behavior of a BENTONE gel must be attributed to some other type of gel building block than the commonly known three-dimensional structure. The important factors are the organic chain bonded to a fixed plate, instead of just adsorbed on it, and the solvation of this chain by a solvent rather than just association. The effect of temperature on a BENTONE gelled system, therefore, is small, because only the association of the molecules of the medium with each other can be changed to any appreciable extent by heat. Even this effect is minimized because the dispersed BENTONE gel system cuts dow

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the amount of van der Waals' association between molecules of the same medium. In practice, the viscosity of a complex pigmented system, containing a small amount of BENTONE, is usually less sensitive to temperature changes than a system with the same viscosity not containing BENTONE.

Limitations of BENTONE Gels

Throughout the major portion of this Handbook, we have called attention to the many unusual advantages of BENTONE 34 in bodying organic systems. There are, however, a number of minor limitations in the use of BENTONE which should be noted. One of the important properties of BENTONE 34 is the water repellency which it imparts to the system in which it is used. By virtue of this decided aversion to water, it would follow that it is not easily wetted.

In addition to the foregoing, BENTONE 34 cannot be used in highly polar solvent systems, such as those noted in the following Section IV. In Table I, "Polarity Classification of Organic Systems As A Guide For Use in BENTONE Gelation", BENTONE 34 will not satisfactorily gel solvents in Groups I-A and I-B. This subject will be thoroughly discussed in Section IV.

While small amounts of the highly polar compounds in Groups I-A and I-B of Table I materially aid in the bodying of BENTONE 34 dispersed in organic compounds listed in Table I, a certain degree of caution is necessary in the use of these highly polar materials, since excessive amounts of them will result in degelling the BENTONE. This also is discussed in Section IV.

Another obvious degelling agency is the introduction into the system of such materials as mineral acids which would break down the BENTONE structure. BENTONE 34 has good tolerance for organic acids above propionic acid.

Lastly, BENTONE 34 should not be used in systems that are operative for long periods of time at temperatures above 400° F.

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IV - FACTORS AFFECTING BENTONE 34 IN USE

In order to develop the excellent properties of BENTONE 34 in organic media, it has been shown that it is necessary to disperse the BENTONE thoroughly throughout the system. Energy must be applied to the BENTONE in the organic system to obtain the ultimate dispersion and the resultant thixotropic properties. This energy may be imparted by mechanical shear action, by the application of moderate heating, by the introduction of polar solvents, or a combination of these three agencies.

Mechanical Shear Action

The characteristics of all the components will markedly affect the shear force required for a given BENTONE-organic system. They will also determine the maximum gel or thickening possible with BENTONE, and the ease of dispersion or thickening.

One of the most obvious factors is in the initial viscosity of the material being processed. Sufficient viscosity of the base medium is necessary to give adequate resistance during the grinding operation, so that the system is subjected to a high shear force. Industry is well aware of this requirement in most instances.

For those systems requiring a grinding step during processing, addition of the BENTONE to the initial mill charge before grinding is normally the best method for incorporation. The inclusion of BENTONE 34 in the original pigment grind is highly desirable for two reasons. First, adequate shear action is assured, and secondly, there is no need for a separate mechanical operation for the dispersion of the BENTONE.

The shear force imparted by a particular piece of equipment will be changed by the characteristics of the system itself, but, in general, a pebble mill, roller mill, or colloid mill can be used effectively.

Pebble Mill

The most efficient grinding apparatus for BENTONE dispersion is a pebble or ball mill. In addition to its high efficiency, the use of the pebble mill also permits the grinding of BENTONE in straight solvent systems which are in many cases too volatile and too fluid for processing on a roller mill.

The pebble mill is an excellent piece of apparatus for producing high BENTONE content masterbatches. By the use of this technique, it is possible to disperse the BENTONE thoroughly in a non-polar solvent in high concentration with a minimum of gelation. Thus, the mill can be easily discharged and the dispersed BENTONE can be readily gelled by the subsequent addition of

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specially selected polar solvents. This latter subject is treated in detail later in this section.

Roller Mill

A roller mill may be used to disperse the BENTONE if certain principles are followed. This will normally entail the addition of a sufficient quantity of BENTONE to yield a paste that will furnish enough resistance to grinding so that sufficient shear force is imparted to the system. In most cases the three-roll paint mill is quite adequate, especially when other pigments are present which contribute to the shear and grinding action on the BENTONE.

The roller mill can also be used to make BENTONE masterbatches. The addition of approximately 25% BENTONE to mineral spirits, to furnish a paste suitable for grinding on a roller mill, is a good example of this technique.

The roller mill is more versatile than a pebble mill in handling heavy pastes and vehicles of high viscosity.

Colloid Mill

The colloid mill is used in the manufacture of a wide range of BENTONE gels. The colloid mill is capable of a high degree of shear force, so that it is often possible to obtain the maximum gelation from the shear force and frictional heat without polar solvent. It is particularly well adapted to gelling relatively high melting materials, such as waxes and asphaltic compounds, where it is necessary to process at elevated temperatures. Like the roller mill, the colloid mill is well suited for continuous operation, permitting high production rates.

Stirring

It is not usually possible to produce a satisfactory gel with BENTONE 34 by stirring alone. In a number of solvent systems, however, where maximum dispersion is not desired, it is possible to produce a BENTONE 34 gel by stirring. In many cases, suspending the BENTONE and thoroughly wetting it in a non-polar liquid, followed by addition of proper polar solvent to this suspension, results in a satisfactory gel with stirring alone. This is particularly true where heat can be applied to the material being stirred. In all of these cases, the stirring apparatus should be capable of developing a high rate of shear.

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Masterbatching

In those cases where it is desirable to use the BENTONE in systems in which sufficient shear action cannot be applied, or where the addition of the BENTONE is done after a pigment grind (as for a final viscosity adjustment), it is possible to add the BENTONE as a masterbatched paste in organic solvent. It is recommended that a concentrate of BENTONE in solvent be prepared, and that this masterbatch be added to the major portion of organic solvent system with stirring.

Any of the previously mentioned types of grinding equipment can be used in masterbatch preparation, and the optimum BENTONE concentration will depend on the type of mill and the organic medium. The typical range recommended is 15 to 25 % BENTONE by weight. The masterbatch grind will develop the maximum gelation of the BENTONE, and provides a concentrated gel which can be conveniently handled and stored.

Addition of a BENTONE-solvent gel paste of cup grease viscosity to a normal paint system will require high speed (800 RPM) agitation or stirring to insure a homogeneous dispersion. This paste may be let down by adding more solvent to the gel, with high speed agitation, before addition to the end products. Addition of BENTONE in very dilute gel systems will entail consideration of the total solvent being added, since this may change the solids-to-solvent ratio.

There is another method used in the paint industry to increase the viscosity of a finished paint with BENTONE. This consists of adding a higher than normal amount to a portion of the finished paint and then grinding in the normal manner. This over-thickened paint can then be used to adjust the consistency of a lower viscosity paint.

Thermal Effects

One of the many advantages of BENTONE as a thickening agent is the fact that excellent gelation is generally obtained by grinding, without the necessity for using heat. This rule holds in the majority of cases. However, it has been noted in several instances that moderate increases in the temperature of the organic solvent have led to easier dispersion of the BENTONE in the solvent. This action may be ascribed to the following effects:

1.) Initial spreading of the montmorillonite platelets by thermal energy through reduction of the attractive forces between platelet and hydrocarbon chain, as well as between platelets.

2.) Effective lowering in the solvation energy level of the hydrocarbon chain.

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3.) Introduction of greater molecular movement, thus affording easier penetration of the inter-platelet spaces by the solvent.

The suggested temperature range to facilitate gelation is 150°F - 175°F. Often the frictional heat developed in the milling operation is sufficient to increase the rate of gelation over that of the shear action alone.

Heat also has the effect, in many systems, of reducing the amount of polar solvent required for maximum gelation.

While we have discussed the effects of heat in the initial formation of BENTONE gels, we should like to emphasize at this point that, once maximum gelation has been achieved in a system, temperature changes no longer affect the behavior of the BENTONE gel. As a matter of fact, the viscosity of such a gel is independent of temperature per se. For this reason, it is especially important that full gelation be obtained in the initial processing.

Polarity of the System

The problems involved in the dispersion of BENTONE in various organic media are fundamentally the same as those generally involved in pigment wetting. The wetting characteristics of a compound are based on its chemical structure. Differences are noted between aromatic and aliphatic structures, and even between branched chain and straight chain aliphatics. The presence of acids, esters, alcohols, unsaturates, and ketones usually increases the ease of dispersion of a pigment in a system. Alkyds will differ from phenolics in wetting properties, as will a high acid content linseed oil compared to an alkali refined linseed oil.

The relative polarity of a particular compound is a function of its wetting properties. Although there is a difference in polarity between toluene and an aliphatic hydrocarbon, for the purposes of this presentation, we are classifying as non-polar such materials as toluene, V. M. & P. naphtha, mineral spirits, gasoline, and aliphatic hydrocarbons. Alcohols and ketones are classified as polar. In addition, there are many compounds of intermediate polarity which have fair wetting characteristics, such as a high acid content vegetable oil.

TABLE I is presented to serve as a guide in the application of BENTONE to a variety of organic systems.

It will be noted that TABLE I consists of Group I, Polar Compounds, and Group II, Non-Polar Compounds. Individual classifications in the table are defined in terms of effective structural groupings. A considerable number of compounds are given as illustrations in each sub-classification.

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TABLE I

POLARITY CLASSIFICATION OF ORGANIC SYSTEMS AS A GUIDE FOR USE IN BENTONE GELATION

GROUP I POLAR COMPOUNDS (Compounds containing a high ratio of oxygenated or other solvating groups relative to their molecular weights)

A. HIGH POLARITY (Low molecular weight alcohols, acids, ketones, esters)

Methanol	Propionic Acid	Methyl Isobutyl Ketone
Ethanol, 95%	Acetone	Low mol. wt. Formate Esters
Formic Acid	Methyl Ethyl Ketone	Low mol. wt. Acetate Esters
Acetic Acid		

B. MEDIUM POLARITY (Compounds similar to A, of somewhat higher molecular weight in relation to the number of functional groups present)

Propanol	Ethylene Glycol	Carbitols
Butanol	Glycerol	Phenol
C_4 to C_8 Acids	Cellosolves	Cresol
		Triethyl Phosphate

C. LOW POLARITY (High molecular weight alcohols, ethers, esters, resins)

Alcohols higher than Butanol	Phthalate Esters	Ethers
Acids higher than Caprylic	Linseed Oil	Amine-Formaldehyde Resins
Tricresyl Phosphate	Castor Oil	Other high mol. wt. Esters
	Alkyds	
	Phenolics	

GROUP II NON-POLAR COMPOUNDS (Members of the hydrocarbon family containing no solvating groups other than double bonds and aromatic rings)

A. HIGH AROMATICITY (Aromatic ring derivatives)

Toluene	Xylene	Benzene

B. MEDIUM AROMATICITY (Compositions containing intermediate proportions of unsaturation, aromaticity or terpene structures. The remaining portion has solvent characteristics typical of aliphatic hydrocarbons)

Turpentine	V. M. & P. Naphtha
Unsaturated Hydrocarbons	Mineral Spirits

C. LOW AROMATICITY (Compositions containing minor proportions of unsaturation or aromaticity. The remaining portion has solvent characteristics typical of aliphatic hydrocarbons)

Kerosene	Low Odor Mineral Spirits	Odorless Mineral Spirits

D. ALIPHATIC (Relatively pure non-cyclic saturated hydrocarbons)

Alkanes	Mineral Oil	Paraffin Waxes

J-57-53

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Groups I-A and I-B are materials which are not effectively gelled by BENTONE 34, by virtue of their strong polarity. The primary function of these polar compounds in BENTONE gelation is to serve as additives to increase the gelation of systems based on compounds lower in the table.

Group I-C compounds gel moderately well with additives. The same is true for Groups II-A and II-B in some instances. The general rule may be made that in going from Group I-C to Group II-D, the gelation of the BENTONE ranges from moderately good to zero, without additives. It should be remembered that the foregoing statements are based on thoroughly dispersed BENTONE.

Many systems, in practice, are a combination of Group I-C and some member of Group II. In such systems, any tendencies toward BENTONE gelation are cumulative. For example, an alkyd (Group I-C) cut in toluene (Group II-A) gels much more readily than one cut in odorless mineral spirits (Group II-C). In fact, the position of the organic medium in this classification governs the amount of polar additive and the amount of energy input (either shear force or heat) required for gelation.

Group I-C is of great practical importance, because it contains most of the materials used industrially as binders, non-volatile vehicles for coatings of all types, and plasticizers. There is a range of gelling properties for any one member of this group, depending upon its molecular weight and how it is modified. For example, a long oil alkyd generally wets easier and gels better than a short oil alkyd. A bodied linseed oil, having a somewhat higher acid number, is more readily gelled with BENTONE than a purified raw linseed oil. Melamine resins and short oil phenolics are usually more difficult to gel, and require a correspondingly better gelling thinner from Group II for good gelation. For all members of Group I-C, these factors must be considered, and compensated for in three ways:

1. Choice of thinners from Group II.
2. Amount of polar additive from Groups I-A and I-B.
3. Amount of energy input required (heat and/or mechanical shear).

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NLI 115347

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32

In Group II-A, compounds with high aromaticity, good gelation of BENTONE is fairly easily obtained. In general, Group II-A is effectively gelled with BENTONE by the use of mechanical work with only a minimum of polar additive from Groups I-A or I-B. The gelation of Group II-B (medium aromatic content) by BENTONE is somewhat more difficult, since Group II-B consists of mixtures of constituents having high aromaticity with larger amounts of non-polar ingredients.

BENTONE 34 can be gelled directly with V. M. & P. naphtha, but only with some difficulty, and by the use of large amounts of shear force, or shear force and heat. The moderate aromaticity of this material aids slightly in the gelling of the BENTONE. Compounds in this classification generally require the use of small amounts of polar solvents from Group I-A and I-B for ease of thickening.

Since Group II-C has extremely low aromaticity, and Group II-D has essentially no aromatic content, they are much poorer wetting solvents and hence require more shear action, and more polar solvent, to obtain good BENTONE gelation. These solvents are very useful in pebble mill masterbatching, where gelation in the mill is undesirable.

Groups I-A and I-B have a very important effect on the gelling characteristics of compounds low in polarity. Small amounts of these materials make gelling of BENTONE much easier, and in many cases increase the ultimate gel strength. The relative effectiveness of the members of each group varies considerably. Alcohols and ketones appear to be effective at the lowest concentrations. In any given homologous series, the lowest molecular weight compound is the most effective. In practice, methanol, ethanol, and acetone are the most widely used polar additives. Triethyl phosphate is of special interest where low volatility is necessary, such as in wax and resin applications. The amounts used in gelling BENTONE 34 vary according to the additive.

The amount of additive employed should always be based on the weight of the BENTONE used. The general range for BENTONE 34 is from 15% to 100% of additive, depending on the combination of factors outlined above. As a specific example, BENTONE 34 in heptane (Group II-D) requires 30% methanol or 60% acetone for maximum gelation. BENTONE 34 in toluene (Group II-A) reaches maximum gelation with only 15% methanol. These figures for BENTONE 34 will vary accordingly for other systems, or for the same system where less efficient dispersion methods are used.

Order of Addition of Polar Constituent

In most cases it is desirable to add the polar constituent after the BENTONE and other materials have been processed by milling. The gelation of a

S-57-53

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volatile aliphatic hydrocarbon by BENTONE 34 is an excellent example of this method. Because of volatility losses and flammability hazards, the grinding of BENTONE 34 in low solvency mineral spirits is best accomplished in a pebble mill. Formation of a high viscosity paste would complicate the discharge of the gelled batch from the mill. Since low solvency mineral spirits has poor wetting characteristics, because of its non-polar nature, normal pebble milling of BENTONE 34 will not gel the system until a polar material such as methyl alcohol is added after the grind. Addition of the methyl alcohol with good stirring, after the pebble milled batch is discharged, completes the gel formation. This method permits easy handling of a thin paste through the plant before the batch is thickened to the final viscosity, and allows a higher solids content mill grind.

On the other hand, inclusion of the polar additive during the initial pigment grind of the base system is, in some cases, the best procedure to follow. The presence of polar solvent during the grind, shortens the grinding time necessary for ultimate gelation of the BENTONE by reducing the amount of shear force required. In addition, the tendency of pigment particles to re-agglomerate during the grind is minimized by the action of the BENTONE gel. The polar solvent is often essential in the case of poor wetting vehicles and pigments, as for example, with phenolic dispersion resin systems.

Degel-tion

It has been shown in the foregoing section regarding the polarity of BENTONE systems, that the judicious use of polar additives makes it possible to produce optimum BENTONE gels with a minimum of mechanical or heat energy input. Experimental data prove that while small amounts of polar additives progressively increase gel strength to a maximum point, when more polar solvent is added, the excess polar constituent brings about marked loss of gel strength. This loss of gel strength, beyond the factor of dilution, is often quite sharp, and may be termed degelation for purposes of this discussion. The phenomenon of degelation of BENTONE gels may be attributed, therefore, to the same factors which originally promoted ease of dispersion. This is shown in Figure XI illustrating the effect of increasing amounts of methanol on the gelation of BENTONE 34 in pure heptane. These data were obtained from a 7.5% suspension of BENTONE 34 in n-heptane which had been pebble-milled for 24 hours. Brookfield curves were run after the addition of methanol with stirring. The significance of the Brookfield curve method shown has been discussed in Section III.

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NLI 115349

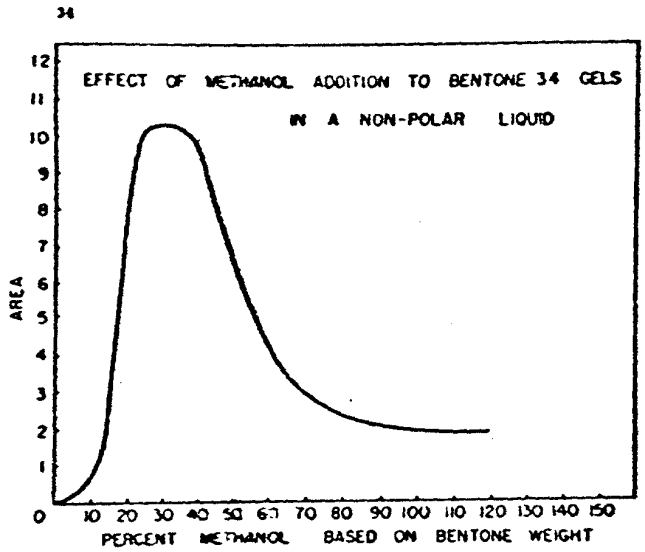

Figure XI

EFFECT OF METHANOL ADDITION TO BENTONE 34 GELS IN A NON-POLAR LIQUID

It will be noted from the curve that the gelation of BENTONE 34 is improved by the addition of absolute methanol up to an optimum point at 30% methanol (based on the weight of the BENTONE). With increasing amounts of methanol, the gel strength falls off rapidly. To avoid any misconceptions due to dilution, all determinations were adjusted so that additive-plus-heptane was a constant total. The degelation is obviously due to greater amounts of polar solvent. Our studies have indicated that the excess polar solvent gradually diminishes the attractive forces between the plates through preferential adsorption, to the point where all attractive forces between the platelets have been overcome, resulting in a completely dispersed group of platelets acting independently.

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V - GENERAL ADVANTAGES OF BENTONE 34

BENTONE 34 has found application in a wide variety of fields where the unique properties of BENTONE gels solve many problems. Such problems are often interrelated, so the effective use of the BENTONE results in solving more than one problem at a time. The purpose of this section is a general description of each beneficial action of BENTONE 34. Wherever possible recommendations will be made as to the approximate amount of BENTONE necessary to obtain these benefits.

1. Improved Brushability

The short, "buttery" gel structure of BENTONE 34 greatly enhances the brushability of paints which tend to pull under the brush. With the advent of the alkyd vehicles as replacements for oleo-resinous vehicles, there has been increased need for such a thixotropic gellant. The "soupy" nature of low solids content paints can also be corrected by the use of BENTONE 34, to provide a paint with a higher apparent viscosity together with a desired short gel structure.

RECOMMENDATION: 1 to 8 lbs. of BENTONE per 100 gallons of paint.

2. Sag Prevention

Sagging has been a pressing problem in the wide field of coatings having a low solids content or a low viscosity vehicle. BENTONE 34 is especially effective in paints and vinyl plastisols by providing a gel which will flow smoothly under working conditions, but will otherwise be resistant to flow of its own accord. The optimum amount of BENTONE used must be determined for each particular system to prevent sagging and yet allow for sufficient levelling.

RECOMMENDATION: 1 to 2½ in vinyl plastisols based on the resin, or 2 to 4 lbs. of BENTONE per 100 gallons of paint.

3. Improvements in Spraying and Dipping Applications

BENTONE 34 greatly reduces the stringiness and cobwebbing frequently encountered in spray-coating operations. The short "buttery" gel imparted by the BENTONE insures a smoother, thicker single coat, while at the same time it acts as a retardant to flow in the baking cycle. These desirable characteristics are also apparent in dip-coating paints and plastisols where a thicker uniform single coat is desired without teardrop formation.

RECOMMENDATION: 1 to 2½ in plastisols based on the resin, or 1 to 4 lbs. of BENTONE per 100 gallons of paint.

S-57-53

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36

4. Pigment Suspension Properties

The hard settling of finely divided silica fillers and metal primer pigments can be very easily remedied by the use of BENTONE 34. Its continuous gel structure effectively cushions the settling particle. In this way, the presence of the BENTONE gel insures easier reincorporation of the settled solids. The exact amount of BENTONE to be used to achieve soft settling depends on the specific gravity of the pigments and on the original viscosity of the vehicle, and thus varies with each paint.

RECOMMENDATION: 2 to 6 lbs. of BENTONE per 100 gallons of paint.

5. Bodying Action and Viscosity Control

One of the outstanding features of BENTONE 34 is its thixotropic bodying action. For each organic system, e.g. paints, plastisols, stains, etc., the consistency is raised proportionately with each small increment of BENTONE added. The viscosity increase is predictable, and its reproducibility from batch to batch is exceptionally good. BENTONE 34 does not require aging to develop maximum gelation, since body is obtained immediately when the proper combination of shear force, heat, and polar additive is applied to the system.

RECOMMENDATION: 2 to 10 lbs. of BENTONE per 100 gallons of paint.

6. Temperature Independence of BENTONE Gels

Normally, the viscosity of gelled organic systems is inversely proportional to the temperature. The BENTONE gels are quite remarkable in that they do not follow the classical relationship of viscosity to temperature. In BENTONE gels, the only change of viscosity with temperature change is the normal variation of the base liquid. Thus, BENTONE 34 is exceptionally well-suited for retarding the excessive flow developed during high temperature curing or baking cycles, e.g. in plastisols, plastigels, hot spray paints, dipping paints, waxes, printing inks, etc.

7. Package and Aging Stability

Systems containing BENTONE 34 do not increase in viscosity or thin out on aging. In properly formulated paints for example, package stability tests of 18 and 24 months duration show that variations from initial viscosity are less than 5%. Such a property is highly desirable for trade sales items where there may be a considerable time lapse between production of the material and consumer application.

8. Color Uniformity through Penetration Control

The coating of porous or absorbent surfaces of stucco, cement, and plaster, with paint, presents a very pressing problem due to the tendency for

L-57-53

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excessive penetration of non-volatile vehicle into the surface. BENTONE 34 is outstanding in effectively gelling the vehicle so that its penetration can be controlled, and yet provides a short gel which will brush easily. The use of BENTONE will help eliminate "shiners" and other color non-uniformities associated with uneven penetration of a paint.

9. Color Uniformity through Flooding Control

BENTONE 34 insures color uniformity by its formation and retention of a homogeneous pigment-vehicle gel structure. This is most notable in systems where the color is a function of more than one pigment, each having varying specific gravities and settling rates. A green paint where iron blue and lead chromate are the color bodies is a good example. In such systems, the BENTONE gel prevents separation of pigments from each other and from the vehicle, which eliminates color striations and variations in color density. At the same time, the tendency for pigment flotation (flooding) in certain paints is counteracted by the BENTONE gel structure.

10. Water Resistance

The hydrophobic nature of BENTONE 34 is highly desirable in organic systems in which moisture resistance is of great importance. The metal primers, adhesives, waxes, and mastic compounds are the most notable applications. In addition to being hydrophobic, BENTONE 34 serves to reinforce the film against prolonged immersion in water by means of the continuous gel structure which it forms between pigment and vehicle. This is a noteworthy property, since many other gelling agents are water susceptible, and tend to accelerate the deterioration and failure of the protective film.

11. Chemical Resistance

BENTONE 34 improves acid and alkali resistance in paints and other protective coatings by decreasing the wettability of the film. Panels coated with two 1.5 mil layers of red lead-Parlon-chlorinated paraffin-BENTONE 34 paint, when immersed in an 18% hydrochloric acid solution for 48 days, showed marked improvement over the control paint without BENTONE. Likewise a red lead-zinc oxide-Pliolite-chlorinated paraffin-BENTONE 34 paint, when immersed in 20% sodium hydroxide solution, showed a definite increase in durability over the control paint containing no BENTONE.

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38

12. Improved Structure Reinforcement

The "coupling" gel between the BENTONE and vehicle serves to strengthen paint films, waxes, adhesives, etc.[12] Typical Pliolite-chlorinated paraffin paints containing BENTONE 34 show remarkably improved durability. Paint films containing no BENTONE show severe checking or alligatoring, whereas after 8 months outdoor exposure, those paint films containing BENTONE 34 (6 to 14 lbs. per 100 gallons of paint) weathered with no indications of these film defects. In paraffin wax having a sharp melting point at 125°F., the inclusion of 8% BENTONE 34 hardens, reinforces, and bodies the wax so that it will not melt, but only soften, at 160°F.

13. Flatting Action in Clear Systems

Although the primary function of the BENTONE is that of gelation, it exhibits a moderate degree of flatting in clear varnishes and lacquers where a soft or satin finish is desired. Unlike most flatting agents, BENTONE 34 does not present a settling problem. One of the ideal uses of the BENTONE is its addition to other flatting agents to prevent hard caking of such materials at the bottom of the container in storage.

RECOMMENDATION: 2 to 8 lbs. of BENTONE per 100 gallons of paint.

14. Effect of BENTONE 34 on Adhesion

Laboratory tests show that BENTONE 34 exhibits no adverse effects upon the adhesion of paint or other films to surfaces which they are coating. These results with BENTONE are in marked contrast to a great number of suspension agents which contribute to poor adhesion because of their undesirable lubricating action.

15. Effect of BENTONE 34 on Solvent Release

The presence of a BENTONE gel does not adversely affect the drying time of a paint system. The rates of evaporation of straight solvent and BENTONE-gelled solvent are almost identical. Unlike other gelling agents, BENTONE-bodied systems do not trap solvent, and therefore they do not prolong the drying of the paint film.

[12] Kornhoff, A. J., Barnard, W., & Bruder, M., "Function of Organophilic Bentonites in Coating Materials", presented before Pacific Northwest Paint & Varnish Production Club, Seattle, Washington, May 26, 1952.

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VI - SPECIFIC APPLICATIONS OF BENTONE 34 (GENERAL FORMULATIONS)

PAINTS

EXTERIOR HOUSE PAINTS

Exterior Primers

For maximum effectiveness, exterior primers must possess certain definite qualities which are readily obtainable through the use of BENTONE. BENTONE 34 will afford these paints good pigment suspension and easier brushability at a higher apparent viscosity level. The strong continuous film developed by BENTONE 34 in primers provides an excellent base for the topcoat. The following general formulation containing BENTONE 34 will serve as a starting point for the formulator, and illustrates the highly desirable properties of BENTONE 34 in exterior primers.

FORMULA I

Primer (Exterior)

Pigment	Pounds	Gallons
Basic Silicate White Lead-45X	266	8.0
TITANOX RANC	108	3.1
Magnesium Silicate (Medium Oil Absorption)	342	14.4
BENTONE 34[1]	6	0.4
Vehicle		
Raw Linseed Oil	374	22.5
Pale Heat Bodied Linseed Oil (Z$_4$) No. 55	185	23.1
60% Ester Gum[2] Solution in Light Mineral Spirits	33	4.3
Light Mineral Spirits	144	22.0
Liquid Drier[3]	16	2.6
Polar Solvent[4]	---	---
	1274	100.4

PVC - 35%

Weight per Gallon 12.7 lbs.

[illegible]

[illegible]

Conforms to Federal Spec. TT-P-[illegible], Type I

[illegible]

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40

Exterior Topcoats

The incorporation of BENTONE 34 in topcoat formulations results in a paint superior in performance and final appearance. BENTONE 34 provides these paints with a controllable increase in viscosity and easier working properties. Its use in topcoats insures better color control by preventing undue penetration and flooding. The incorporation of BENTONE 34 in topcoats gives strong film reinforcement without impairing the other characteristics of these paints. The following formulations are general examples of exterior topcoats containing BENTONE 34.

FORMULA 2

Topcoat (Exterior)

Pigment	Pounds	Gallons
Basic Silicate White Lead-45X	176	5.3
Zinc Oxide (Aircular)	232	5.0
TITANOX A (MO)	138	4.2
Magnesium Silicate (High Oil Absorption)	257	10.8
BENTONE 34[1]	6	0.4
Vehicle		
nA Varnish Oil No. 37	256	33.1
Dutch Oil Refined No. 61	88	11.0
Pale Heat Bodied Linseed Oil (Z,) No. 35	106	13.2
Light Mineral Spirits	90	13.8
Liquid Drier[2]	22	3.2
Polar Solvent[3]	---	---
	1371	100.0

PV - 31 %
Weight per Gallon 13.7 lbs.

[illegible]

[illegible]

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S-57-53

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FORMULA 3

Fume Resistant Topcoat (Exterior)

Pigment	Pounds	Gallons
TITANOX A 168 (MO)	177.2	5.5
Zinc Oxide (Acicular)	266.5	5.7
Magnesium Silicate (Medium Oil Absorption)	201.6	8.5
BENTONE 34[1]	6.0	0.4
Vehicle		
Alkali Refined Linseed Oil	321.3	41.5
"X" Viscosity Linseed Oil	107.1	13.5
Light Mineral Spirits	159.5	24.4
5% Calcium Naphthenate	5.8	0.7
6% Cobalt Naphthenate	4.8	0.8
Polar Solvent[2]	----	----
	1249.8	100.8

PV - 26.7%
Weight per Gallon - 12.4 lbs.

[1] Include in initial pigment grind.
[2] The addition of 20-40% of polar solvent such as methanol or [illegible] based on the weight of the BENTONE) is recommended for maximum effectiveness in gelation with BENTONE 34. See Section IV, pp. [illegible].

Sash and Trim Paints

When employed in the formulation of sash and trim paints, BENTONE 34 contributes many beneficial properties. Chief among these is the easier brushability resulting from a desirable increase in thixotropy. From the standpoint of final appearance, the action of BENTONE 34 is notable in the elimination of sagging. BENTONE 34 will also insure uniformity in color and gloss through its control of flooding and penetration. The following formulation containing BENTONE 34 provides an excellent example of a sash and trim paint for the initial consideration of the paint formulator.

J-57-53

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42

FORMULA 4 **Blue Sash and Trim Enamel**

Pigment	Pounds	Gallons
TITANOX RANC	38.0	1.1
Whiting (Low Oil Absorption)	55.0	2.4
Phthalocyanine Blue (72% Color)	25.0	1.6
BENTONE 34[1]	3.0	0.2
Vehicle		
Alkyd Solution (70% Solids)[2]	624.0	77.0
Light Mineral Spirits	121.0	18.5
24% Lead Naphthenate	2.9	0.3
6% Cobalt Naphthenate	0.8	0.1
Soya Lecthin	2.0	0.2
Polar Solvent[3]	----	----
	871.7	101.4

PV - 9.8%

Weight per Gallon - 8.6 lbs.

[1] Include in initial pigment grind.

[2] Conforms to Federal Spec. TT-[illegible], Type I, Class A.

[3] The addition of 20-40% of polar solvent such as methanol or denatured ethanol (based on the weight of the BENTONE) is recommended for maximum effectiveness in gelation with BENTONE 34. See Section IV, pp. [illegible].

INTERIOR HOUSE PAINTS

Wall Primer-Sealers

The major requirements in this type of paint are controlled penetration and the formation of a strong continuous sealing film. BENTONE 34 is especially useful in controlling penetration, and its film reinforcing properties supplement the film integrity for better service life. BENTONE 34 also improves brushability and gives more uniform viscosity control. The following example illustrates the proper use of BENTONE 34 in a wall primer-sealer.

J-57-53

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FORMULA 5

Wall Primer-Sealer (Interior)

Pigment	Pounds	Gallons
TITANOX RCHT	300	11.1
Atomite	100	4.4
Zinc Oxide (Fine Particle)	10	0.2
BENTONE 34[1]	15	1.0
Vehicle		
Phthalic Anhydride-Safflower Alkyd (60% Solids)[2]	270	35.0
Heavy Mineral Spirits	105	15.0
Light Mineral Spirits	237	35.0
24% Lead Naphthenate	7.5	0.8
6% Cobalt Naphthenate	4	0.5
4% Calcium Naphthenate	2	0.3
Anti-Skinning Agent	1.6	0.2
Polar Solvent[3]	----	----
	1052.1	103.5

PV - 46.4%

Weight per Gallon - 10.2 lbs.

[1] Include in initial pigment grind.

[2] 10-12% Phthalic Anhydride. Viscosity V to Z. Acid No. 10 to 25.

[3] The addition of 20-40% of polar solvent such as methanol or denatured ethanol (based on the weight of the BENTONE) is recommended for maximum effectiveness in gelation with BENTONE 34. See Section IV, pp. 29-33.

Interior Enamels

BENTONE 34 is quite effective in giving interior enamels a thixotropic viscosity, with good brushability. It also insures sag prevention and good color uniformity. The gloss of the enamel finish is not impaired when up to 4 lbs. of BENTONE 34 per 100 gallons of paint are used, providing the BENTONE is well-ground and dispersed. At higher BENTONE concentrations a desirable satin-like flatting effect is achieved. The following formulations, containing

J-57-53

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44

BENTONE 34, are good starting points for illustrating the effectiveness and performance of BENTONE 34 in gloss enamels.

FORMULA 6

Painters' Enamel

Pigment	Pounds	Gallons
TITANOX RA	150	4.3
TITANOX RCHTX	300	11.1
Zinc Oxide (Fine Particle)	15	0.3
BENTONE 34[1]	4	0.3
Vehicle		
Short Oil PE-Maleic Ester Gum Varnish (75% Solids)[2]	317	48.0
Phthalic Anhydride-Safflower Alkyd (60% Solids)[3]	135	17.5
Light Mineral Spirits	203	30.0
24% Lead Naphthenate	7.5	0.3
6% Cobalt Naphthenate	4	0.3
Anti-Skinning Agent	0.8	0.1
Polar Solvent[4]	----	----
	1136.3	104.9

PV - 29.8%
Weight per Gallon - 10.8 lbs.

[1] See note on bodied pigment grind.
[2] Viscosity Z1 to Z2, Acid No. 4 to 8, Oil Length - 30 gal. Safflower.
[3] 50-52% Phthalic Anhydride, Viscosity T to X, Acid No. 10 to 20.
[4] The addition of 20-40% of polar solvent such as methanol or denatured ethanol based on the weight of the BENTONE is recommended for maximum effectiveness in systems with BENTONE 34. See Section IV, pp. 20-22.

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45

FORMULA 7

Painters' Enamel

Pigment	Pounds	Gallons
TITANOX RA	200	5.7
TITANOX RCHT	250	9.3
Witcarb P	75	3.3
BENTONE 34[1]	5	0.3
Vehicle		
Duraplex D-65A[2]	268	33.5
60% Ester Gum[3] Solution in Light Mineral Spirits	86.5	11.0
Syntex 1260 B[4]	28.3	4.0
Ardol (Maleic-Soya Oil)	39.7	5.0
Heavy Mineral Spirits	168	24.0
24% Lead Naphthenate	4.8	0.5
6% Cobalt Naphthenate	4	0.5
1% Aerosol OT in Water	1.7	0.3
Polar Solvent[5]	-----	----
	1131.0	97.4

PV - 35.9%
Weight per Gallon - 11.67 lbs.

[1] Include in initial pigment grind.
[2] 34% Phthalic Anhydride - Soya Alkyd, 70% Solids.
[3] Acid No. 8-10.
[4] Modified Soya-Chlorinated Oil, 60% Solids.
[5] The addition of 20-40% of polar solvent such as methanol or dimethyl ethanol based on the weight of the BENTONE 34 is recommended for maximum efficiency in systems with BENTONE 34. See Bentone 19, pp. 20-22.

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46

FORMULA 8

Semi-Gloss Enamel

Pigment	Pounds	Gallons
TITANOX RANC	350	10.0
Precipitated Whiting	175	7.9
Celite 281 (Medium Oil Absorption Diatomaceous Silica)	35	1.8
BENTONE 34[1]	4	0.3
Vehicle		
Syntex 70 (24.5% Phthalic Anhydride-Soya Alkyd; 65% Solids)	427	54.0
Light Mineral Spirits	169.5	26.0
24% Lead Naphthenate	3.5	0.4
6% Cobalt Naphthenate	2.3	0.3
Anti-Skinning Agent	1.0	0.1
Polar Solvent[2]	-----	----
	1167.3	100.8

PV - 39.5%

Weight per Gallon - 11.6 lbs.

[1] Include in initial pigment grind.

[2] The addition of 30-40% of polar solvent such as methanol or denatured ethanol based on the weight of the BENTONE) is recommended for maximum effectiveness in gelation with BENTONE 34. See Section IV, pp. 30-33.

Interior Flats

The action of BENTONE 34 makes it especially well-suited for use in interior flat paints. The most outstanding properties imparted by BENTONE 34 are its excellent control of penetration and flooding, which insure color uniformity. Interior flats containing BENTONE 34 are easier to brush and free from sagging, due to the characteristic bodying effect of the BENTONE. The following formulation is an example of the use of BENTONE 34 in interior flats.

J-57-53

00057

NLI 115362

47

FORMULA 9

Interior Flat – Light Tint Base

Pigment	Pounds	Gallons
TITANOX RCHTX	440	16.3
Atomite	175	8.0
Diatomaceous Silica	45	2.3
BENTONE 34[1]	10	0.7
Vehicle		
1952 Wallkyd[2]	380	47.5
Low Odor Mineral Spirits	160	25.2
24% Lead Naphthenate	3	0.3
6% Cobalt Naphthenate	2	0.3
Anti-Skinning Agent	1	0.1
Polar Solvent[3]	—	—
	1216	100.7

PV - 67.0%

Weight per Gallon - 12.1 lbs.

[1] Include in initial pigment grind.

[2] 32% Phthalic Anhydride-Soya Alkyd, 40% Solids.

[3] The addition of 20-30% of polar solvent [illegible] in the weight of the BENTONE 34 [illegible] BENTONE 34. See Section IV, pp. 20-33.

J-57-63

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00057

NLI 115363

46

FORMULA 10

Interior Flat - Tinting Base

Pigment	Pounds	Gallons
TITANOX RCHT	503.6	18.7
LORITE	127.2	6.0
BENTONE 34[1]	7.0	6.5
Vehicle		
Oil Varnish[2]	290.1	38.2
Ester Gum Solution[3]	82.6	10.6
Light Mineral Spirits	186.2	28.4
Kerosene	21.2	3.2
24% Lead Naphthenate	9.1	1.0
5% Cobalt Naphthenate	2.6	9.3
Polar Solvent[4]	-----	----
	1229.6	106.9

PV - 45%

Weight per Gallon - 11.5 lbs.

[1] Include in initial pigment grind.

[2] Heat processed linseed-dehydrated castor oil (1/3) at 70% non-volatile in mineral spirits; Viscosity V.

[3] 10 Pound Cut of Ester Gum (Acid No. 6-10) in Light Mineral Spirits.

[4] The addition of 30-40% of polar solvent such as methanol or denatured ethanol (based on the weight of the BENTONE) is recommended for maximum effectiveness in gelation with BENTONE 34. See Section IV, pp. 29-33.

J-57-53

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NLI 115364

FORMULA 11

Interior Flat - Deep Tone Base

Pigment	Pounds	Gallons
TITANOX RCHTX	50	1.9
Micronized Mica	100	4.3
Aluminum Silicate (Coarse Grade)	200	9.2
Zinc Oxide (Fine Particle)	5	0.1
BENTONE 34[1]	15	1.0
Vehicle		
Phthalic Anhydride Safflower Alkyd (60% Solids)[2]	231	30.0
Heavy Mineral Spirits	350	50.0
24% Lead Naphthenate	7.5	0.8
6% Cobalt Naphthenate	4	0.5
4% Calcium Naphthenate	2	0.3
Soya Lecithin	4	0.5
Anti-Skinning Agent	1.6	0.2
Polar Solvent[3]	-----	----
	970.1	98.8

PV - 49.5%

Weight per Gallon - 9.8 lbs.

[1] Include in initial pigment grind.

[2] 10-12% Phthalic Anhydride, Viscosity Y to Z, Acid No. 10 to 20.

[3] The addition of 20-40% of polar solvent such as methanol or denatured ethanol flooded on the weight of the BENTONE is recommended for maximum effectiveness in gelation with BENTONE 34. See Section IV, pp. 20-28.

Interior Flats of Low Solids Content

Considerable interest has been shown in flat wall paints having much lower vehicle and pigment solids than the conventional types. A thinner film with equivalent performance is desirable where frequent recoating builds up an objectional film thickness. A major problem, however, is the very low working viscosity resulting when the low-hiding extender pigments are removed. BENTONE 34 offers a most promising new approach to the low-solids paint field.

J-57-53

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NLI 115365

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58

The paint can be bodied to any desired consistency, with excellent non-sagging, controlled penetration, and pigment suspension properties. The following formulation is given as a starting example of what can be accomplished with BENTONE. This paint has a consistency of 82 Krebs Units (Stormer) as shown; without the BENTONE it is so thin that it is off the scale on the Stormer measurement.

FORMULA 12

Interior Flat Wall Paint — Low Solids

Pigment	Pounds	Gallons
TITANOX RA	161.2	4.6
Celite 281 (Medium Oil Absorption Diatomaceous Silica)	77.5	4.0
BENTONE 34[1]	13.2	0.9
Vehicle		
Admerol 400 RS[2]	460	65.8
Sovasol 5 (Light Mineral Spirits)	158	24.2
24% Lead Naphthenate	2.4	0.2
6% Cobalt Naphthenate	1.2	0.2
Soya Lecithin	1.1	0.1
Anti-Skinning Agent	0.6	0.1
Polar Solvent[3]	-----	----
	875.2	100.1

PV - 35.0%

Weight per Gallon - 8.8 lbs.

[1] Include in initial pigment grind.

[2] Include in initial pigment grind.

[3] Soya-Styrylopentadiene Copolymer; 32% Solids.

[4] The addition of 20-40% of polar solvent such as methanol or dimethyl ethanol found on the weight of the BENTONE is recommended for maximum effectiveness in gelation with BENTONE 34. See Section IV, pp. 20-25.

J-57-53

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NLI 115366

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Stipple Paints

A stipple paint is usually applied over a sealed surface and allowed to partially set, before the stippling design is imparted to the surface. By using BENTONE 34 in stipple paint, the stipple effect may be produced immediately on application of the paint to the base coat. BENTONE 34 stipple paints eliminate the usual waiting period and the irregularities which often result. BENTONE 34 effectively controls the sagging or running tendencies, without impairing the workability of the stipple coating. Shown below are two stipple paints based on the use of BENTONE 34.

FORMULA 13

Flat Stipple Paint

Pigment	Pounds	Gallons
TITANOX RCHTX	527	19.4
400 Mesh Silica	88	4.0
LORITE	88	4.1
"DUTCH BOY" TRIBASE	2.6	0.04
BENTONE 34[1]	9-11	0.5-0.7
Vehicle		
Ardanco V-160 (Limed Linseed Oil)	350	49.4
Heavy Mineral Spirits	145	21.6
24% Lead Naphthenate	1.8	0.2
6% Cobalt Naphthenate	0.9	0.1
Polar Solvent[2]	-----	----
	1214.3	99.5

PV - 62%

Weight per gallon - 12.2 lbs.

[1] Include in initial pigment grind. The lower amount gives a rounder stipple, while the higher amount gives a sharper and higher stipple.

[2] The addition of 20-40% of polar solvent such as methanol of denatured ethanol (based on the weight of the BENTONE) is recommended for maximum effectiveness in gelation with BENTONE 34. See Section IV, pp. 20-22.

J-57-33

00057

NLI 115367

53

FORMULA 14

Gloss Stipple Paint

Pigment	Pounds	Gallons
TITANOX RCHTX	448	16.6
TITANOX RA	53	1.5
Witcarb P	28	1.2
"DUTCH BOY" TRIBASE	2.6	0.04
BENTONE 34[1]	8-10	0.5-0.7
Vehicle		
60% Ester Gum[2] Solution in Light Mineral Spirits	190	21.4
Dehydrated Castor Oil	105	13.5
Ardol (Maleic Soya Oil)	114	14.5
Shell 42 Thinner[3]	36	4.8
Heavy Mineral Spirits	148	22.0
24% Lead Naphthenate	6.3	0.7
6% Cobalt Naphthenate	2.1	0.3
Polar Solvent[4]	-----	----
	1141.0	100.2

PV - 32.8%

Weight per Gallon - 11.4 lbs.

[1] Include in initial pigment grind. The lower amount gives a smoother stipple, while the higher amount gives a rougher and higher stipple.

[2] Acid No. 6 to 10.

[3] Boiling Range 305°-380°F., Flash Point 140°F., KB Value 73. Approximately 91% Aromatics.

[4] The addition of 20-60% of polar solvent such as methanol or denatured ethanol based on the weight of the BENTONE is recommended for maximum effectiveness in gelation with BENTONE 34. See Section IV, pp. 20-26.

S-57-53

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NLI 115368

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METAL PROTECTIVE PAINTS

The benefits arising from the action of BENTONE 34 in metal protective paints are outstanding and unique. The most notable of these contributions is the excellent pigment suspension made possible by BENTONE 34. BENTONE 34 imparts improved moisture resistance and water repellency, insuring a film strongly reinforced against the damaging effects of weathering. The working properties of these paints are greatly improved when they contain BENTONE 34. It is possible to apply thicker, uniform, single coats with favorable reduction of sag. BENTONE 34 has no adverse effect on adhesion of the paint to the metal surface, and offers no impairment to drying. The following general formulations are examples of the use of BENTONE 34 in metal protective paints.

FORMULA 15

Red Lead-Alkyd Primer

Pigment	Pounds	Gallons
Red Lead, 97%	1302	17.8
BENTONE 34[1]	8	0.5
Vehicle		
Alkyd Resin Solution[2]	504	64.6
Light Mineral Spirits	108.4	16.2
6% Cobalt Naphthenate	1.8	0.2
Polar Solvent[3]	-----	----
	1924.2	99.1

PW - 48.2%
Weight per Gallon - 19.4 lbs.

[illegible]

[illegible]

[illegible]

J-57-53

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NLI 115369

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54

FORMULA 16

Mixed Pigment-Alkyd Primer

Pigment	Pounds	Gallons
Red Lead, 95%	380	5.1
Zinc Yellow	70	2.3
Mica, 325 Mesh (Water Ground)	65	2.8
Indian Red	10	0.2
Magnesium Silicate (Medium Oil Absorption)	160	6.7
BENTONE 34[1]	6	0.4
Vehicle		
Alkyd Resin Solution[2]	415	51.3
Light Mineral Spirits	193	28.4
Dipentine	25	3.5
24% Lead Naphthenate	4.7	0.5
6% Cobalt Naphthenate	4.7	0.6
Polar Solvent[3]	----	----
	1330.4	104.8

PV - 35%

Weight per Gallon - 13.1 lbs.

[1] Include to initial pigment grind.

[2] Conforms to Federal Spec. TT-R-266, Type I, Class A.

[3] The addition of 20-60% of polar solvent such as methanol or denatured ethanol (based on the weight of the BENTONE) is recommended for maximum effectiveness in gelation with BENTONE 34. See Section 10, pp. 20-33.

The following formulation is for a light metal alloy primer, based on Military Specification MIL-P-6889A. It illustrates the use of BENTONE 34 as a pigment suspending agent in a primer which must meet a severe settling test. The specification test, involving dilution with two and one-half volumes of toluene and observation of the system on standing, is extremely difficult to meet in regular plant production. The formulation given below passes this test successfully, due to the action of BENTONE 34.

J-57-53

00057

NLI 115370

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FORMULA 17

Light Metal Alloy Primer

Pigment	Pounds	Gallons
Zinc Yellow (Low Salt Content)	252	8.6
Magnesium Silicate (Medium Oil Absorption)	40	1.7
BENTONE 34[1]	4.3	0.3
Vehicle		
60% Alkyd Resin Solution[2]	248	29.5
Bakelite BK-3962 (50% Solids Phenolic Resin Solution)	171	20.1
Malic Acid	1.4	0.1
Xylene	281	38.9
24% Lead Naphthenate	2.7	0.3
6% Cobalt Naphthenate	0.9	0.1
Anti-Skinning Agent	0.9	0.1
Soya Lecithin	2.6	0.3
Polar Solvent[3]	-----	----
	1004.8	100.0

PV - 30.2%

Weight per Gallon - 10.0 lbs.

[1] Include in initial pigment grind.

[2] As Specified in MIL-P-[illegible].

[3] The addition of 20-40% of polar solvent such as methanol or denatured ethanol (based on the weight of the BENTONE) is recommended for maximum effectiveness in gelation with BENTONE 34. See Section [illegible], pp. [illegible].

RUBBER-BASE PAINTS (STYRENE-BUTADIENE AND CHLORINATED RUBBER)

Since these paints are designed primarily for stucco, concrete, and cement, they must have outstanding weathering resistance. BENTONE 34 markedly improves the film durability of rubber-based paints. A styrene-butadiene control paint showed severe checking and "alligatoring" after 6 months exposure. The same paint containing 6 lbs. of BENTONE 34 per 100 gallons weathered without any "alligatoring" or checking. BENTONE 34 improves the brushing, eliminates the sagging, and controls penetration in these low solids content

J-57-53

00057

NLI 115371

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56

paints. BENTONE 34 gels an otherwise thin or soupy paint to a higher apparent viscosity without any loss in good working properties. BENTONE 34 improves rubber-base paints without retarding the solvent release of the volatile portion of the vehicle. This is in marked contrast to the action of most other gellants, which generally prolong drying and soften the paint film. Tests conducted on the following typical formulations will demonstrate the performance of BENTONE 34 in these paints.

FORMULA 18

Styrene-Butadiene Concrete or Stucco Paint

Pigment	Pounds	Gallons
TITANOX RANC	374	10.7
"DUTCH BOY" DYPHOS[1]	2	0.03
BENTONE 34[2]	6	0.4
Vehicle		
Pliolite S-5	200	22.9
Chlorowax 40	20	2.1
Raw Tung Oil	10	1.3
Hi-flash Naphtha	214	29.5
Light Mineral Spirits	214	32.7
Polar Solvent[3]	---	----
	1040	99.6

PV - 29.8%
Weight per Gallon - 10.4 lbs.

[1] "DUTCH BOY" DYPHOS, dibasic lead phosphate, is a fine white pigment, which prevents soft-[illegible] and other effects resulting from the degradation of the chlorine-containing [illegible] in the film. It protects the film against the ultra-violet rays of the sun and the effects of high temperatures. Since DYPHOS is white and has a high hiding strength (refractive index of 2.25), it should be considered a part of the total pigment requirement of the paint.

[2] Include in total pigment grind.

[3] The addition of 20-40% of polar solvent such as methanol or denatured ethanol (based on the weight of the BENTONE) is recommended for maximum effectiveness in gelation with BENTONE 34. See Section IV, pp. 20-32.

J-57-53

00057

NLI 115372

FORMULA 19

Chlorinated Rubber Concrete or Stucco Paint

Pigment	Pounds	Gallons
TITANOX RANC	250	7.2
"DUTCH BOY" DYPHOS[1]	16	0.3
BENTONE 34[2]	6	0.4
Vehicle		
Parlon (10 cps)	123	9.0
Rezyl 869 (100% Solids)	123	13.3
Xylol	510	70.5
Epichlorohydrin	0.6	0.01
24% Lead Naphthenate	1.6	0.2
6% Cobalt Naphthenate	0.8	0.1
Polar Solvent[3]	-----	----
	1031.0	101.1

PV - 26.0%

Weight per Gallon - 10.2 lbs.

[1] "DUTCH BOY" DYPHOS, [illegible] lead phosphate, is a low [illegible] pigment, which [illegible] [illegible] and other effects [illegible] from the [illegible] of the [illegible] [illegible] in the film. It protects the film against the [illegible] of the sun and the effects of [illegible] temperatures. Since DYPHOS is white and has a [illegible] strength (retractive index of 1.25), it should be considered a part of the total white pigment requirement of the paint.

Include in initial pigment grind.

[2] The addition of 20-40% of polar solvent such as methanol or denatured ethanol [illegible] on the weight of the BENTONE is recommended for maximum effectiveness in gelation with BENTONE 34. See Section IV, pp. 29-33.

J-57-53

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NLI 115373

58

FORMULA 20

Chlorinated Rubber Concrete or Stucco Paint

Pigment	Pounds	Gallons
TITANOX RANC	232	6.6
Zinc Oxide (Acicular)	46	1.0
Mica, 325 Mesh (Water Ground)	70	3.0
Magnesium Silicate (Medium Oil Absorption)	117	4.9
"DUTCH BOY" DYPHOS	8	0.1
BENTONE 34[1]	28	1.9
Vehicle		
Parlon (20 cps.)	60	4.4
Clorafin 42-S	15	1.5
Thermolyzed Tung Oil (O'Brien 976)	15	1.9
Duraplex D-65A[2]	28	3.5
Aromatic Mineral Spirits[3]	341	47.9
Aromatic Mineral Spirits[4]	132	17.8
Turpentine	36	5.0
Epichlorohydrin	0.3	0.0[illegible]
6% Cobalt Naphthenate	0.3	0.04
Polar Solvent[5]	-----	----
	1128.6	99.6

PV - 63.5%

Weight per Gallon 11.4 lbs.

[1] Include in initial pigment grind.

[2] 20% Formalin / [illegible] Alkyd, 70% Solids.

[3] Boiling Range 315°-362°F., Approximately 34% Aromatics, K.B. Value 73.5.

[4] Boiling Range 315°-402°F., Approximately 93% Aromatics, K.B. Value 63.

[5] The addition of 20-40% of polar solvent such as methanol or [illegible] [illegible] on the weight of the BENTONE 34 is recommended for maximum effectiveness to gelation with BENTONE 34. See Section [illegible], pp. [illegible].

J-57-53

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NLI 115374

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ASPHALT PAINTS

Exposure durability is the major problem with these paints, and it is here that BENTONE 34 is especially effective in reinforcing the paint film. Softening of the coating under the heat of the sun and embrittlement in cold weather are minimized by this film reinforcing action. The tendency of these paints to sag is overcome by small amounts of BENTONE 34, which at the same time does not adversely affect the solvent release and drying time. The following formulations are well suited for dip or spray application.

FORMULA 21

Asphalt Paint (For Metal Surfaces)

	Pounds	Gallons
Gilsonite	112	12.8
Cottonseed Pitch	42	5.5
BENTONE 34[1]	10	0.7
Refined Linseed Oil	280	33.6
Heat bodied "Q" Linseed Oil	89	11.2
Light Mineral Spirits	183	28.0
Turpentine	20	2.8
Kerosene	38	5.6
Polar Solvent[2]	---	---
	754	100.0

Weight per Gallon - 7.5 lbs.

[1] BENTONE 34 may be incorporated on the down leaf of the rock between 150°-250°F., or may be masterbatched in a colloid mill with a portion of [illegible], oil and [illegible]. See Section IV, p. 20.

[2] The addition of 30-40% of polar solvent such as methanol or denatured ethanol (based on the weight of the BENTONE) is recommended for maximum effectiveness in pigment with BENTONE 34. See Section IV, pp. 29-30.

J-57-53

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NLI 115375

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60

FORMULA 22

Asphalt Paint (For Wood Surfaces)

	Pounds	Gallons
Gilsonite	191	21.4
Cottonseed Pitch	134	17.5
Dark Wood Rosin	20	2.2
BENTONE 34[1]	10	0.7
Refined Linseed Oil	36	4.7
Light Mineral Spirits	263	40.2
Heavy Mineral Spirits	89	13.3
Polar Solvent[2]	---	----
	743	100.0

Weight per Gallon - 7.4 lbs.

[1] BENTONE 34 may be incorporated in the down heat of the cook between 150°F-250°F, or may be [illegible] in a colloid mill with a portion of resin, oil and thinner. See Section IV, p. [illegible].

[2] The addition of [illegible] of polar solvent such as methanol or denatured ethanol (based on the weight of the BENTONE) is recommended for maximum effectiveness in gelation with BENTONE 34. See Section IV, pp. [illegible].

Inert pigments are frequently employed in asphalt paints, although the two formulations shown above contain none. In such cases, BENTONE 34 overcomes hard settling of the extender pigments.

CLEAR FINISHES

BENTONE 34 has proven exceptionally effective in improving the working properties of clear finishes. Both sagging and running are greatly reduced by its use. Moreover, there is no appreciable reduction in gloss or clarity of the finish when the BENTONE 34 (1 to 4 lbs. per 100 gallons) is thoroughly dispersed by pebble mill grinding. A remarkably soft, satin finish is obtained when larger amounts of BENTONE 34 are used. It does not present a settling problem, unlike most other flatting agents. An ideal application for BENTONE 34 is in conjunction with other flatting agents to keep them from settling hard. BENTONE 34 also promotes good uniformity in such finishes by maintaining a thorough and even dispersion of the flatting pigment. In the following

J-57-53

00057

NLI 115376

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formulation, BENTONE 34 is used to improve the performance of the silica flatting pigment in a typical flat varnish.

FORMULA 23

Flat Oleoresinous Varnish

	Pounds
Phenolic - PE - Rosin - Dehydrated Castor Oil Varnish[1]	565
Santocel C (Silica Aerogel)	30
BENTONE 34[2]	4
Mineral Spirits (Adjust to desired consistency)	24
	623

[1] Varnish Composition

	Pounds
Bakelite [illegible] (Phenolic Resin)	[illegible]
Pentalyn G [illegible] (Rosin Derivative)	[illegible]
Canning [illegible] Oil (Dehydrated Castor Oil)	[illegible]
[illegible] Lead Naphthenate	[illegible]
[illegible] Cobalt Naphthenate	[illegible]
Light Mineral Spirits	[illegible]

Varnish Cook. Heat oil and resin to [illegible], and hold 70-75 minutes. Cool to [illegible], and add mineral spirits and driers.

[2] BENTONE 34 may be manufactured with a portion of the varnish and thinner. See Section [illegible], p. [illegible].

TRAFFIC PAINTS

Traffic paints and zone marking paints are formulated for fast drying, low angular sheen, bleeding resistance, and high abrasion resistance under severe conditions of wear. BENTONE 34 is especially useful in these paints because it is possible to achieve bodying without retarding solvent release, allowing the paint to set within a few minutes after application. One technique of making reflecting types of traffic paints is to include glass beads directly in the ready mixed paint. The hard packing of these beads has been a problem

J-57-53

00057

NLI 115377

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62

which is successfully eliminated through the use of BENTONE. BENTONE 34 does not affect adhesion of the paint film, which is an important consideration in the anchoring of the glass beads in the finished product. In addition, the BENTONE film reinforcing action is an asset in promoting durability of the paint in use.

FORMULA 24

Traffic Paint

Pigment	Pounds	Gallons
TITANOX RCHT	389	13.7
LORITE	198	9.3
BENTONE 34[1]	5	0.3
Vehicle		
Aroplaz 1085-V Solution (50% Solids Phthalic Anhydride Alkyd)	520	58.3
Textile Spirits[2]	42	6.9
24% Lead Naphthenate	10.4	1.1
6% Cobalt Naphthenate	2.7	0.3
Anti-Skinning Agent	0.2	0.1
Polar Solvent[3]	----	----
	1147.3	100.0

PV - 45.2%

Weight per Gallon - 11.5 lbs.

[1] Include in initial pigment grind.

[2] Boiling Range 140°-175° F., U.S. Value 14.3.

[3] The addition of 20-40% of polar solvent such as methanol or denatured ethanol [illegible] on the weight of the BENTONE [illegible] is recommended for maximum effectiveness in gelation with BENTONE 34. See Section IV, pp. [illegible].

MAINTENANCE PAINTS

The incorporation of BENTONE 34 in maintenance paints, such as mill white finishes, has proven to be particularly advantageous. BENTONE 34 enhances the working properties of such paint systems to a marked degree by

J-57-53

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NLI 115378

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improving brushability, and by preventing sagging and hard pigment settling. By closely controlling vehicle penetration, the BENTONE insures a high degree of color and gloss uniformity in these paints. In addition, the BENTONE will increase the moisture resistance and film strength of this type of finish.

FORMULA 25

Eggshell Mill White

Pigment	Pounds	Gallons
TITANOX RCHT	445	16.5
TITANOX RA	222	6.8
Zinc Oxide (Fine Particle)	47	1.0
Atomite	89	4.0
Magnesium Silicate (Extremely Fine)	23	0.9
BENTONE 34[1]	9	0.6
Vehicle		
Medium Oil Length Soya Alkyd (60% Solids)[2]	413	53.7
Light Mineral Spirits	102	15.5
24% Lead Naphthenate	9.2	1.0
6% Cobalt Naphthenate	3.8	0.5
Polar Solvent[3]	----	----
	1363.0	100.5

PV - 51.0%
Weight per Gallon - 13.6 lbs.

[1] Include in initial pigment grind.
[2] 30% Phthalic Anhydride-Soya Alkyd, Viscosity Z_1 - Z_2.
[3] The addition of 20-40% of polar solvent such as methanol or denatured ethanol (based on the weight of the BENTONE) is recommended for maximum effectiveness in gelation with BENTONE 34. See Section IV, pp. 20-22.

J-57-53

00057

NLI 115379

64

STAINS

A stain is a special type of coating with low pigmentation, which is designed primarily to impart color effects to a surface, rather than protection. The coloring matter may be a pigment or some form of natural or synthetic dyestuff. The range of vehicles used is very large, including water and water-dispersible binders, alcohol, turpentine, oils, natural and synthetic resins, and many combinations of these materials.

Many stains are quite low in viscosity and must be applied very carefully in order to minimize streaking or the formation of pools on horizontal surfaces, and sagging on vertical surfaces. Small amounts of BENTONE 34 are highly effective in controlling the flow characteristics, and consequently, the film thickness of the stain. This makes the application technique much less critical for obtaining a smooth, even appearance on the finished work. BENTONE 34 also controls penetration, which is especially helpful in obtaining even shades on surfaces of irregular porosity. "Bleeding" or migration of colorant into other coatings is minimized by the mineral-organic matter "coupling" effect of BENTONE in the dried film. One further important advantage is the package stability imparted to pigmented stains through greatly improved pigment suspension.

An example of an exterior shingle stain and an interior oil wood stain for furniture, employing BENTONE 34, are shown below. In general, the amount of BENTONE 34 necessary to improve the application and performance of a stain may vary from 2 to 10 lbs. per hundred gallons. The quantities depend largely on the degree of bodying, sag control, and penetration control desired.

FURNITURE STAINS

BENTONE 34 greatly improves pigment suspension as shown in the following pigmented stain. Uniform application is easier because of its excellent flow properties and controlled penetration into the wood.

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FORMULA 26

Interior Oil Wood Stain

Pigment	Pounds	Gallons
Burnt Umber	100	3.3
BENTONE 34[1]	4	0.3
Vehicle		
Oleoresinous Varnish[2]	70	9.6
Raw Linseed Oil	19	2.4
Limed Rosin Solution (64% Solids in Mineral Spirits)	7.1	0.9
Light Mineral Spirits	491	75.0
6% Manganese Tallate	54.3	6.7
24% Lead Tallate	8.5	0.9
Polar Solvent[3]	----	----
	711.9	99.1

PV - 34.3%
Weight per Gallon 7.2 lbs.

[1] Include in initial pigment grind.
[2] 50 gal. Tung-Dehydrated Castor PE-Ester Gum Varnish, Viscosity F to G, 40% Solids.
[3] The addition of 20-40% of polar solvent such as methanol or denatured ethanol (based on the weight of the BENTONE) is recommended for maximum effectiveness in gelation with BENTONE 34. See Section IV, pp. 20-21.

SHINGLE STAINS

These stains are usually applied by dipping or brushing. BENTONE 34 will effectively control the bad sagging and draining tendency of such products. Easier application, uniform film thickness, and improved penetration control are insured by BENTONE 34. Poor package stability due to pigment packing, and non-uniform staining resulting from faulty pigment distribution, are also minimized.

J-57-53

00057

NLI 115381

66

FORMULA 27

Shingle Stain

Pigment	Pounds	Gallons
CP Chrome Green (Medium)	45	1.5
BENTONE 34[1]	6	0.4
Vehicle		
70% Solids Soya Alkyd[2]	345	43.1
Aromatic Mineral Spirits[3]	104	14.6
Light Mineral Spirits	276	42.1
5% Pentachlorophenol Solution	5.2	0.6
24% Lead Naphthenate	5.2	0.5
6% Cobalt Naphthenate	1.8	0.2
Polar Solvent[4]	-----	----
	788.2	103.0

PVF - 6.5%

Weight per Gallon - 7.7 lbs.

[1] [illegible] to initial pigment grind.

[2] Conforms to Federal Spec. TT-R-266, Type I, Class A.

[3] Approximate Boiling Range 300°-400° F., K.B. Value 28.

[4] The addition of 20-40% of polar solvents such as methanol or denatured ethanol based on the weight of the BENTONE 34 is recommended for maximum effectiveness in gelation with BENTONE 34. See Bentone 57, pp. 20-23.

SHOE STAINS

Shoe stains are similar in principle to wood stains. They contain dyes, usually with some waxes, which are incorporated into a relatively small amount of varnish to form a heavy paste. These mixes are then let down with solvents to very low consistencies. BENTONE 34 provides unequalled control of body and pigment suspension in these systems, contributing greatly to easy application and uniform results. The reinforcement of the wax and varnish bodies by BENTONE, and the improved resistance to water, enhance the durability of the stained surface.

L-57-53

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89

67

MASTIC COMPOUNDS

PUTTY, CAULKING COMPOUNDS, AND WOOD FILLERS

There are several basic problems in the production and performance of these highly pigmented systems which BENTONE 34 solves very effectively. The initial wetting of whiting and other fillers by the non-volatile vehicle is improved by the action of the BENTONE gel in preventing re-agglomeration of particles. In actual practice, the need for "sweating" a freshly prepared batch is virtually eliminated.

The storage properties of the putty, caulking compound, or wood filler are strikingly improved with BENTONE 34. Package stability tests with such compounds, for as long as two years, show very little oil separation or hardening. Small amounts of BENTONE 34 keep the composition homogeneous. This eliminates most of the tedious reworking which has usually been required before application.

The beneficial effect of BENTONE gels on pliability and spreading characteristics is valuable in maintaining the proper balance of working properties. The adjustment of flow properties can be made without affecting the adhesion, rate of setting, or final hardness of the product.

BENTONE 34 improves the performance of the putty, caulking compound, or wood filler after it has been applied. Due to the reinforcing action of the BENTONE gel system, dimensional stability is improved. The moisture resistance of the composition is increased by the water repellent nature of BENTONE 34. Since rate of setting, adhesion, and hardening characteristics are not changed by BENTONE 34, it is not necessary to reformulate a proven trade item in order to take advantage of these benefits.

BENTONE gels are quite independent of temperature, and they tend to minimize changes of working properties in mastic compositions with changes in temperature. It is thus possible to formulate a single putty or caulking compound for both cool and hot weather application.

From 1.5% to 2.5% of BENTONE 34 (based on the oil content) is recommended for putty, caulking compounds, and wood fillers. The best practice is to grind the BENTONE into a small portion of the oil on a roller mill or colloid mill prior to incorporation with the other pigments. While it is somewhat less efficient, direct incorporation in a Baker-Perkins mixer or in a putty chaser is used successfully in industry. The following typical formulations give examples of the use of BENTONE 34 in a sash putty and a paste wood filler.

9-27-53

00057

NLI 115383

68

FORMULA 28

Sash Putty

	Pounds	Gallons
OOLITIC F[1]	1230	54.9
No. 55 Putty Powder[1]	410	18.3
BENTONE 34	3.8	0.3
Raw Linseed Oil	187.5	24.2
Light Mineral Spirits	9	1.4
Liquid Drier[2]	8	1.2
	1848.3	100.3

[1]Whitings of specially selected particle size.

[2]Conforms to Federal Spec. TT-D-631, Type I.

Note: In many cases it may be advantageous to add a small amount of polar solvent in accordance with the principles given in Section IV, pp. 20-33.

FORMULA 29

Paste Wood Filler

	Pounds	Gallons
Pulverized Silica	475	21.6
Diatomaceous Silica	475	28.5
Magnesium Silicate (Medium Oil Absorption)	190	8.0
BENTONE 34	3	0.2
Raw Linseed Oil	111	14.3
Limed Rosin Solution (64% Solids in Mineral Spirits)	4.2	0.5
Light Mineral Spirits	122	18.6
Toluene	41	5.7
6% Manganese Tallate	32.5	4.0
24% Lead Tallate	5.1	0.5
	1458.8	101.9

Note: In many cases it may be advantageous to add a small amount of polar solvent in accordance with the principles given in Section IV, pp. 20-33.

J-57-53

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NLI 115384

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69

NON-INFLAMMABLE PAINT AND VARNISH REMOVERS

BENTONE 34 is ideally suited for bodying non-inflammable paint removers to a paste consistency. Removers gelled with BENTONE 34 are easy to handle and apply. The reproducibility of the viscosity increase obtained with the BENTONE is outstanding. Changes in viscosity of the paste with changing temperatures are greatly minimized by the presence of the unique BENTONE gel. The gel structure imparted by BENTONE 34 provides excellent package and storage stability.

The BENTONE-gelled paint remover is highly thixotropic and resists flow after application. This property is highly desirable in removing small areas of paint without affecting the rest of the paint film. Moreover, BENTONE paint removers do not leave a waxy or soapy residue after removal of the paint. No further cleaning is necessary before repainting.

BENTONE 34 finds best application in the non-inflammable type of paint removers which are essentially non-polar in character. Incorporation of 5 to 10% BENTONE 34 by pebble mill grinding will furnish maximum gelation.

FORMULA 30

Non-Inflammable Paste Remover

	Pounds
Methylene Chloride	58
Carbon Tetrachloride	28
Ethyl Alcohol, 95%	2
BENTONE 34	7
Paraplex G-50[1]	5
	100

[1]Paraplex G-50 is a high molecular weight linear polyester. Its function in this formula is to improve the paint removing action by delaying solvent volatilization.

PRINTING INKS

The dispersion of finely divided pigments in vehicles to produce a material that is suitable as a printing ink is an exceedingly complex art. The type of surface being printed, the particular printing press being used, the speed of

S-57-53

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NLI 115385

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79

operation, and the time of drying are all basic factors which determine the necessary working qualities for a satisfactory ink.

The constant aim of the printing industry has been to increase press speeds. This has required printing inks which set rapidly. Resin-based systems which can be dried by water, steam or hot air are gradually replacing the drying oils. Modern high speed presses require inks which will set in a matter of seconds rather than minutes.

For high speed printing, inks must maintain a proper balance of tack, penetration, and body control. Too high a degree of tack may cause the paper to tear or the ink to mist at high press speeds. Ink with insufficient tackiness will not transfer properly in the printing operation. If penetration of the ink is too great, the print becomes visible from the opposite side of the paper, or causes blurring of figures. Poorly controlled penetration may result in smudging after the ink has been supposedly set. An ink must have body to prevent centrifugal throw-off at high press speeds. Indiscriminate bodying, however, is not the answer. Too viscous an ink will not flow properly from the fountains to the rollers.

Such variation in the conditions that are to be met makes it mandatory for the ink trade to rely on a large number of formulations. Basically, however, the performance of an ink, whether it be letter press, lithographic, or rotogravure, will be established by its flow properties.

BENTONE 34 is an effective aid in the manufacture of inks. The gel structure of BENTONE 34 in printing inks is invaluable in obtaining the proper balance of working properties. It has proven advantageous in controlling consistency, tack, and penetration. The addition of 3% BENTONE 34 to a newsprint ink will reduce tack and eliminate most of the normal misting on presses operating at speeds of 900 to 1500 linear feet per minute. Additions of 4% of BENTONE 34 to the same ink virtually eliminates this throw-off. BENTONE 34 does a unique job in controlling consistency without adversely affecting solvent release during the printing and setting operations. Penetration of the printing ink is closely controlled by BENTONE 34. This allows the use of substantial quantities of low boiling volatile solvents, useful in quick-drying inks.

TYPOGRAPHIC INKS

Typographic or letterpress inks vary from the highly fluid news inks to magazine and bookbinders inks, which have a much heavier consistency. These inks usually are set by some combination of penetration, oxidation, and forced evaporation.

L-57-53

00057

NLI 115386

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71

Heat-Set Newsprint Ink

Newspapers, telephone books, etc. are usually printed on porous stocks at high press speeds. Newsprint inks dry mainly by penetration and absorption, although some heat is utilized to speed drying and prevent smudging. Costs being of prime importance, newsprint inks have been formulated traditionally with relatively cheap ingredients. BENTONE 34, by controlling viscosity and tack, and therefore penetration and centrifugal throw-off, fulfills a pressing need. A sample black ink formulation is as follows:

FORMULA 31

Heat-Set Black Newsprint Ink

	Pounds
Mineral Oil	100
Dark Wood Rosin	4
Carbon Black	15
BENTONE 34[1]	1-4
	123

[1] For maximum effectiveness, BENTONE 34 should be added to the ink in accordance with the principles of incorporation given in Section IV, pp. 28-34.

In the above formulation, mineral oil may be replaced with a portion of fairly heavy bodied asphaltic residues, mixed with varying amounts of light petroleum fractions. These fractions do not volatilize rapidly at room temperatures, but are readily evaporated when high temperature forced air heating is applied to the paper being printed. Blacker news inks can be made by incorporation of a small quantity of methyl violet toner or similar blue colorant. Satisfactory inks of other colors may be made by substituting other colored oil soluble dyes or toners in proper quantities to give the ink the desired color and flow characteristics.

Other Heat-Set Typographic Inks

High grade inks for periodicals, of a quality superior to newsprint inks, contain vehicles (essentially binders plus solvents) which are not volatile at room temperatures. The following is a good example of the use of BENTONE 34 in a better quality typographic ink in which tack, body, and penetration are controlled.

S-57-53

00057

NLJ 115387

72

FORMULA 32

Non-Smudging Heat-Set Black Typographic Ink

	Pounds
Varnish (Modified Phenol-Formaldehyde Ester Gum Varnish; 40% Solids)	65
No. 5 Litho Varnish (Bodied Linseed Oil)	5
Carbon Black	19
Talc	2
Prussian Blue in Linseed Oil (50%)	4
Alkaline Blue in Linseed Oil (40%)	4
BENTONE 34[1]	3-4
	103

[1] For maximum effectiveness, BENTONE 34 should be added to the ink in accordance with the principles of incorporation given on Section IV, pp. 31-34.

Inks of this type are extremely flexible and non-smudging. They print well and set rapidly at high temperatures.

Water- or Steam-Set Typographic Inks

A water- or steam-set ink may be defined as an ink in which a certain portion of the vehicle comprises higher alcohols or glycols, which are miscible in water, mixed with water insoluble resins. When such an ink is applied, it may be water-set or steam-set by diluting the water miscible portion of the vehicle in such a manner that the remaining resin precipitates and sets rapidly.

The use of BENTONE 34 in steam- or water-set inks will not greatly affect the body, due to the polar solvent content. The presence of BENTONE 34 will control tack, by producing a characteristic shortness in the ink. The overall printing properties of the ink at high press speeds will be greatly improved.

L-57-53

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00057

NLI 115388

FORMULA 33

Steam-Set Black Typographic Ink

	Pounds
Resin (Maleic Rosin Modified)	28.8
Triethanolamine Resinate	14.4
Diethylene Glycol	33.8
Carbon Black	10
Milori Blue Pigment	5
BENTONE 34[1]	3-4
	104.6

[1] For maximum effectiveness, BENTONE 34 should be added to the ink in accordance with the prescription of incorporation given in Section IV, pp. 36-38.

LITHOGRAPHIC INKS

Lithographic printing inks are very similar in composition to typographic inks, except that body is somewhat greater, and pigment concentration is higher. Lithographic off-set printing is the process for printing on sheet metal to be used for making tin cans and other containers. The benefits and principles of the use of the BENTONE given above apply here also.

INTAGLIO (ROTOGRAVURE) INKS

In general, intaglio inks have a more fluid consistency than other types of inks. Solvents are more volatile and setting is based on evaporation. For rotogravure work, a copper cylinder is employed, and soft pigments must be used. BENTONE 34 does an effective job here as in other inks. Since evaporation is the means of drying the ink, it is noteworthy that the BENTONE does not impair solvent release. BENTONE 34 has an extremely small particle size, (1.0 micron) and when properly dispersed, will not injure or deface the relatively soft metal plates used in the intaglio process.

VINYL DISPERSIONS

Vinyl dispersion resins are a special class of vinyl chloride polymers which are designed for use in the general form of pastes. They are readily formulated over a range of viscosities, which makes them adaptable to dipping, spraying, spreading, and cold molding.

L-57-53

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74

A fluid mixture of dispersion resin, plasticizer, and pigments is usually defined as a plastisol. The addition of relatively volatile thinners or diluents produces a composition known as an organosol. A plastisol which has been thickened to a putty-like consistency is termed a plastigel.

Close viscosity control is extremely important in the application of vinyl dispersions. The vinyl dispersion must have sufficiently good flow properties to allow smooth, even application, and yet not be too fluid. BENTONE 34 has proven to be an effective flow control agent for such compounds. It prevents excessive sagging, run-off, and penetration, through its ability to increase thixotropy in the system. BENTONE 34 imparts a marked degree of dimensional stability to vinyl dispersion systems at curing or fusion temperatures, which allows the retention of uniformity and detail.

PLASTISOLS and ORGANOSOLS

The reproducibility of the bodying action of BENTONE 34 is outstanding in plastisols. Since the amount of BENTONE gelation is predictable, the formulator can easily control plastisol viscosities from batch to batch.

From 1 to 2% of BENTONE 34 (based on the resin content) in a dipping plastisol controls sagging, penetration and pigment settling. As the amount of BENTONE 34 is increased, the compounder can easily produce plastisols ranging from dipping to trowelable consistency. When the BENTONE 34 is increased to 3 to 5%, the plastisol becomes stiff and dough-like.

A major problem involved in applying organosols and plastisols is to obtain a uniform coat. BENTONE 34 effectively controls sagging, penetration, and the thickness of the coating. In this connection, the unique property of BENTONE gels in bodying, without affecting solvent release, is of tremendous advantage in forming a stronger and harder film.

The following formulation illustrates the use of BENTONE 34 in a typical plastisol.

S-57-53

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NLI 115390

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FORMULA 34

Dipping Plastisol

	Pounds
Geon 121 or Vinylite QYNV	100
Dioctyl Phthalate	38
Dioctyl Adipate or Dioctyl Sebacate	15
40% Chloroparaffin	10
Atomite	0-10
"DUTCH BOY" DYPHOS[1]	5
"DUTCH BOY" DS-207[1]	2
BENTONE 34[2]	1-2
	182

[1] "DUTCH BOY" Vinyl Stabilizers.

[2] It is recommended that a masterbatch paste of BENTONE 34, stabilizers, and colorants in plasticizer be milled to customer requirements. See Section IV, p. 28. This concentrated paste should be added to the balance of the plastisol with stirring.

PLASTIGELS

Plastigels are the most recent development in the vinyl plastisol field. When enough BENTONE 34 is added to a plastisol to body it to a dough-like consistency, it can be molded or extruded at room temperature and then cured in a hot oil bath or oven without losing dimensional stability.

The severe heat history necessary for proper fusion or curing of a plastigel makes the problem of stabilization extremely important. The most effective heat and light stabilizer system is a combination of "DUTCH BOY" DYPHOS and DS-207.

A typical BENTONE plastigel formulation is shown below.

FORMULA 35

Modeling Plastigel

	Pounds
Geon 121 or Vinylite QYNV	100
Dioctyl Phthalate	60
Atomite	25
"DUTCH BOY" DYPHOS[1]	5
"DUTCH BOY" DS-207[1]	1.5
BENTONE 34[2]	4
	195.5

[1] "DUTCH BOY" Vinyl Stabilizers.

[2] It is recommended that a masterbatch paste of BENTONE 34, stabilizers, and colorants in plasticizer be milled to customer requirements. See Section IV, p. 28. This concentrated paste should be added to the balance of the plastisol on a Baker-Perkins mixer or other suitable piece of heavy laboratory equipment.

L-57-53

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NLI 115391

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78

WAX REINFORCEMENT

It is often economically desirable to increase the melting point, hardness, and tensile strength of the cheaper waxes in order to approach the general characteristics of the more costly and scarcer hard wax products. BENTONE 34 is highly effective in upgrading a wide variety of waxes, regardless of whether the wax is of mineral, vegetable, or animal origin.

The incorporation of BENTONE 34 in a wax raises the softening point of the *pure or untreated* wax. A BENTONE-*reinforced* wax does not melt, and even at the firepoint of the wax, it does not become a true liquid. BENTONE 34 will increase the tensile strength of waxes two-fold and even more.

The amount of BENTONE 34 necessary to improve the physical properties of the waxes is usually 1 to 10% by weight. Incorporation of 8 to 10% of BENTONE 34 in typical paraffin waxes, increases the softening point by 35°F. The tensile strength of a beeswax containing 1 to 4% BENTONE 34 is more than doubled. The same beeswax containing 10% BENTONE 34 cakes but does not liquefy at 350°F.

The exact amount of BENTONE 34 required will vary depending upon the type of wax employed, and the particular physical properties desired.

BENTONE 34 is an excellent bodying agent for liquid waxes. It will also prevent hard settling of crystallized wax particles and facilitate their redispersion. The film deposited by a liquid wax containing BENTONE 34 exhibits a marked improvement in uniformity and durability. The water resistance of the film is also improved by BENTONE 34 due to its inherent water-repellent nature.

BENTONE 34 should be thoroughly incorporated in order to obtain the maximum advantages in the finished wax composition. It is preferable that BENTONE 34 be ground into the molten wax on a colloid mill or other suitable grinding equipment. Other methods, such as stirring a pre-gel into molten wax, have also been employed. It is advisable to incorporate small amounts of polar solvent (usually 20 to 40% based on the weight of BENTONE 34) to facilitate complete dispersion of the BENTONE (see Section IV, pp. 28-33). The choice of polar solvent is determined by the wax processing conditions, and it may be volatilized, if necessary, from the finished bodied wax.

SYNTHETIC RESIN ADHESIVES

About one-third of the organic adhesives in use today may be classified as synthetic resin adhesives. The chief types of these are based on phenolic and *tar acid resins, urea and melamine resins, resorcinol-formaldehyde resins,* and elastomers such as rubber and synthetic polymers. Without further detail

S-57-53

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NLI 115392

77

as to the many and varied combinations the modern adhesives formulator develops from these bases, his ultimate aim is to achieve two prime requisites in an adhesive:

(1) Reasonable handling and application characteristics.

(2) Satisfactory performance in holding joined surfaces together.

The introduction of BENTONE 34 provides the resin adhesives industry with a new tool for modifying several properties which are important in reaching this goal. In solvent-type cements, the gel structure of BENTONE 34 builds up an expanded adhesive-gel lattice, which increases the yield-point characteristics of the product. This permits the use of lower solids content adhesives, and effectively reduces the resin or elastomer solids applied per coat. The result is easier application and better strength characteristics. The soft gel structure which BENTONE adds to the system greatly improves brushability and sprayability, with excellent control of cobwebbing. In the case of a heavier bodied spreading type of adhesive, the BENTONE gel structure improves knifing properties, cutting down the tendency of the material to ball up or form a bank ahead of the blade.

Excessive "striking in" of a relatively thin adhesive is readily controlled with BENTONE 34. Unlike other thickening agents, BENTONE raises the viscosity without affecting solvent release, and consequently curing time is unaffected while strike-in is minimized.

BENTONE 34 reinforces the cured or dry synthetic resin adhesive bond markedly, and at the same time improves its water resistance. Other reinforcing pigments which build up shear strength are available, but none with the unique combination of water resistance and bond-strengthening possessed by BENTONE 34. A typical Buna N-phenolic resin cement was tested to show the effect of BENTONE. The following figures show shear strength tests made on a bonded aluminum-wood combination.

	Cement without BENTONE	Cement with BENTONE
24 hours after cure	720 psi.	935 psi.
24 hours after water immersion	325 psi.	490 psi.

There are many complex and varied formulations employed in the synthetic resin adhesives industry. For the purpose of illustrating the use of BENTONE 34, an elementary recipe is shown below. This is an inner tube patch cement, commonly sold in tubes or small cans. In more involved formulations which include many modifiers, the same general application holds true. The incorporation principles discussed in Section IV should be followed.

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NLI 115393

78

FORMULA 36

Inner Tube Patch Cement

	Pounds	Gallons
No. 1 Smoked Sheets	100	13.2
BENTONE 34	15	1.9
Benzene	1200	164.3
	1315	178.4

OTHER BENTONE APPLICATIONS

The advantages and special characteristics of BENTONE gels have been thoroughly discussed, both in theory and in practice. There are a great many specialized fields and products in which BENTONE 34 supplies its unique properties to great advantage. Some of the applications outlined in the following pages are well established in industry, while others are in a preliminary state of development. Undoubtedly there will be additional future uses outside the scope of this section.

Hydraulic Fluids

Many types of hydraulic fluids must be designed to meet special service conditions. Some of the most rigorous requirements are found in hydraulic fluids for aircraft. The extremes of temperature which are regularly encountered in normal aircraft operation create a problem in maintaining uniform viscosity. The bodying of a low freezing point organic liquid with BENTONE 34, to the proper consistency, is an effective method of obtaining the desired properties.

Drawing Compounds

Drawing compounds are compositions used as die lubricants in the drawing of wire and tubing. Most of these products are essentially a suspension of graphite in mineral oil or some similar base. The incorporation of BENTONE 34 has eliminated the long standing problem of graphite settling in storage. The BENTONE itself contributes materially to improved lubrication, and controls the flow properties at elevated temperatures.

Buffing and Cutting Compounds

These dispersions of abrasive materials in suitable organic liquid carriers tend to settle hard in the package. BENTONE 34 gels improve the

F-57-53

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suspension of the abrasive, making reincorporation easy and preventing agglomeration of the particles. In addition, they are quite effective in reducing the tendency of these compounds to fly off from the wheel during polishing or grinding.

Polyesters

The effective thickening of many monomeric esters by BENTONE 34 provides a useful method for controlling flow properties, and permits improved application before polymerization. The thickness of dipped and spread coatings, and the shaping of complex forms, can be controlled without running or sagging during curing. The finished product has improved tensile strength and dimensional stability.

Colors-in-Oil

For many years, master painters have been accustomed to the use of "tube colors" in meeting their particular tinting requirements. In modern practice, this has been extended to national trade paint systems, in which standard blending bases are converted to any of a multitude of color shades by the householder. The high pigment volumes in colors-in-oil, and the necessity of long term storage in the package contribute to an acute problem in hard packing. Hard packing makes the removal of the product from the tube or can very difficult, but even more important, any resultant streaking or lumping seriously impairs the control of color tone. The properties of BENTONE 34 gels are ideal for colors-in-oil. BENTONE 34 is now successfully used to prevent hard settling and to maintain far better color uniformity, particularly in mixed pigment systems. By preventing phase separation and keeping the tinting system homogeneous, the BENTONE gel structure helps the colors to mix more easily and completely with the base paint. The gel also assists in maintaining tinting uniformity in the finished paint, whether pastel or deep tone.

Silk-Screen Printing Inks

Many printing inks and paint-like compositions are developed especially for the silk-screen printing process. As such, careful control of flow properties is a prime requisite. The general advantage of BENTONE 34 in these products is its ability to add thixotropic body in a purely inert and mechanical way, without affecting chemical reactions, drying time, adhesion, and delicately balanced pigment-vehicle combinations. Excellent control of penetration can be achieved without basic changes in formulation. Where necessary, the film solids deposited in the printing process can be reduced by the addition of BENTONE-gelled thinner.

S-57-53

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86

Emulsion Systems

At first glance it would seem that the water-resistant nature of BENTONE 34 in organic films would reduce its usefulness in emulsions. Actually, emulsions containing BENTONE can be prepared quite satisfactorily, and several desirable and unique properties are contributed to these systems by the BENTONE. One method of preparation is the emulsification of an organic liquid in which BENTONE has been previously gelled. This is particularly useful where a pigment grind in the organic phase is normally carried out. The properties of the BENTONE do not include any appreciable effect on the viscosity of the emulsion, and actually are confined to the organic portion of the system. The action of the BENTONE comes into play where the emulsion breaks, as in the deposition of a film, or when mechanical properties of the organic phase predominate, as in suspension of abrasives or pigments, surface activity, etc. While there is much work yet to be done on the action of the BENTONE in emulsions, it would appear that BENTONE is an orienting structure which does not have soap-type characteristics. It contains an organophilic phase, (the hydrocarbon chains) and an inorganic base which is hydrophilic under the proper conditions.

Latex Paints

Paints based on a colloidally dispersed organic phase in water have attracted very great interest in modern paint technology. Because of their advantages in cost and application properties, they appear to have a most promising future. At present, they face several basic shortcomings, which have proven difficult to overcome or minimize in their formulation. The properties of BENTONE 34 are ideal for these points in which latex paints are deficient. It contributes reinforcement, water resistance and film forming characteristics, coupled with chemical inertness. In the latex paint before application, pigment settling and the reagglomeration of pigment particles are greatly reduced by BENTONE. Through the improvement in the wetting of pigment particles by the organic phase, BENTONE 34 prolongs the useful package life of the latex paint. After the paint has been applied, BENTONE aids the process of film formation by improving the coalescing of the discrete spheres of vehicle. This helps to bring about tighter initial film formation, which is the first step towards better performance of the paint. Similar to the conventional paint systems previously discussed, the use of BENTONE 34 results in the reinforcement and increases moisture resistance of the dried film. Thus, the resultant film shows improved scrub resistance. In addition to these valuable improvements in the latex paint system, the BENTONE is inert and does not interfere with the normal reactivities set up by the formulator.

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31

Other Emulsion Systems

Emulsion polishes and cleaners constitute one of the most promising fields for the application of BENTONE. Improved pigment suspension and reinforcement of the finished film are of special interest in auto, floor, furniture, shoe, and metal polishes and cleaners.

A large class of commercial cutting oils is based on oil-in-water or water-in-oil emulsions. The lubricating properties of the short BENTONE gel and its capacity for suspending particles are particularly beneficial.

A novel application of the pigment suspending property of BENTONE gels had been made in emulsion rug cleaners and in dry cleaning soap systems. The presence of BENTONE in the emulsion prevents redeposition and reagglomeration of carbon black and other extraneous matter, after removal from the fabric.

Some other typical commercial emulsion products in which BENTONE 34 is of interest include wax textile sizings, disinfectants and deodorants, and insecticides.

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82

VII - CONCLUSION

The foregoing pages have indicated the general usefulness of "DUTCH BOY" BENTONE 34. The wide variety of applications and specific problems, however, which the formulator in the paint, plastics, mastic compounds and adhesives industries encounters are beyond the scope of any manual. The Research Laboratories of the National Lead Company and the Research Laboratories of the Baroid Division are constantly working to increase the over-all knowledge in the application of the BENTONES. As additional information becomes available and new products are developed, factual data will be promptly issued to industry.

Representatives of the Technical Service Department are available at all times to discuss individual problems in confidence and indicate the best methods for using "DUTCH BOY" BENTONE 34 based upon research laboratory data.

The reader is cordially invited to write or call the nearest Branch Office of the National Lead Company and will receive prompt attention in getting all the information and technical assistance available.

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BUFFALO 3, NEW YORK
116 Oak Street

CINCINNATI 3, OHIO
659 Freeman Avenue

CHICAGO 8, ILLINOIS
900 West 18th Street

PITTSBURGH 12, PENNSYLVANIA
1376 River Avenue

ST. LOUIS 1, MISSOURI
722 Chestnut Street

LOS ANGELES 23, CALIFORNIA
3113 East 26th Street

CLEVELAND 13, OHIO
1778 Columbus Road

SAN FRANCISCO 10, CALIFORNIA
2240 20th Street

DALLAS 2, TEXAS
959 Terminal Street

PHILADELPHIA 25, PENNSYLVANIA
2627 East Cumberland Street

ATLANTA, GEORGIA
400 Bishop Street, N.W.

SEATTLE 4, WASHINGTON
1128 West Spokane Street

BOSTON 6, MASSACHUSETTS
NATIONAL LEAD CO. of Massachusetts
800 Albany Street

Canadian Titanium Pigments Limited
630 Dorchester Street West
Montreal, Quebec, Canada

Canadian Titanium Pigments Limited
Terminal Warehouse
Foot of York Street
Toronto, Ontario, Canada

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VIII - MATERIALS AND MANUFACTURERS

We are aware that many of the products used in the formulations which appear in the "DUTCH BOY" BENTONE HANDBOOK may be unfamiliar to the reader. Accordingly, we have compiled the following list of materials together with their respective manufacturers. It should be remembered that this list does not include the names of all materials useful in these formulations. All products could not be tested.

Product	Manufacturer
AA Varnish Oil No. 37	National Lead Company
Admerol 400 RS	Archer-Daniels-Midland Company
Aerosol OT	American Cyanamid Company
Ardol	Archer-Daniels-Midland Company
Ardunco V-160	Archer-Daniels-Midland Company
Aroplaz 1085-V	U. S. Industrial Chemicals Company
Atomite	Thompson-Weinman and Company
Bakelite BK-3962	Bakelite Company (Div. U.C.C. Corp.)
Bakelite BR-9400	Bakelite Company (Div. U.C.C. Corp.)
Basic Silicate White Lead - 45X	National Lead Company
BENTONE 34	National Lead Company
Castung 103 GH	Baker Castor Oil Company
Celite 281	Johns-Manville Corporation
Chlorowax 40	Diamond Alkali Company
Chlorafin 42-S	Hercules Powder Company
Duraplex D-65A	Rohm and Haas Company
"DUTCH BOY" DS-207	National Lead Company
"DUTCH BOY" DYPHOS	National Lead Company
"DUTCH BOY" TRIBASE	National Lead Company
Dutch Oil Refined No. 61	National Lead Company
Geon 121	B. F. Goudrich Chemical Company
LORITE	DeLore Div., National Lead Company
OOLITIC F	DeLore Div., National Lead Company
Pale Heat Bodied Linseed Oil (Z_2) No. 55	National Lead Company
Paraplex G-50	Rohm and Haas Company
Parlon	Hercules Powder Company
Pentalyn G	Hercules Powder Company
Pliolite S-5	Goodyear Tire and Rubber Company
No. 55 Putty Powder	DeLore Div., National Lead Company
Rezyl 869	American Cyanamid Company
Santocel C	Monsanto Chemical Company
Shell 42 Thinner	Shell Chemical Company
Sovasol No. 5	Socony-Vacuum Oil Company
Syntex 70	Jones-Dabney Company
Syntex 1260 B	Jones-Dabney Company
Thermolyzed Tung Oil	O'Brien Company
TITANOX Pigments	Titanium Div., National Lead Company
Vinylite QYNV	Bakelite Company (Div. U.C.C. Corp.)
1952 Wallboard	Reichhold Chemicals, Inc.
Wilcarb P	Wilco Chemical Company

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NOTE

The recommendations made in this booklet are based on our research and the research of others, and are believed to be accurate. No guarantee of their accuracy is made, however, and the products discussed are sold without warranty, express or implied, and upon condition that purchasers shall make their own tests to determine the suitability of such products for their particular purposes. Likewise, statements concerning the possible use of these products are not intended as recommendations to use these products in infringement of any patent.

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