PLAINTIFF'S EXHIBIT
UC-3956

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COMPARATIVE PERFORMANCE CHARACTERISTICS OF *CALIDRIA* R-G 244/POLYESTER RESIN SYSTEMS

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COMPARATIVE PERFORMANCE CHARACTERISTICS OF *CALIDRIA* R-G 244/POLYESTER RESIN SYSTEMS

CALIDRIA Resin-Grade 244 Asbestos, a new, modified asbestos fiber from UNION CARBIDE, developed for maximum thickening efficiency and thixotropy in polyester spray-up and hand lay-up laminating resins, is also an effective thickener for plastisols and organosols used in a broad variety of adhesives, coatings, mastics and sealants. In many systems, CALIDRIA Resin-Grade 244 Asbestos will not contribute color or opacity – a characteristic that makes it particularly attractive in polyester gel coats.

The distinctive characteristics of CALIDRIA Asbestos offer improved viscosity and thixotropic properties to polyester resin systems, superior to other commonly used thixotropic aids, at a considerable cost savings. On a pound-for-pound basis, CALIDRIA Resin-Grade 244 Asbestos has been found to contribute more than twice the viscosity of a typical pyrogenic silica. Savings up to 30 per cent or more are illustrated.

Though CALIDRIA Resin-Grade 244 Asbestos is designed for use in stir-in mixers, optimum efficiency and lowest cost are obtained through use of high-shear mixers such as "Cowles" Dissolvers, sonic dispersers and homogenizers.

Other desirable features of CALIDRIA Resin-Grade 244 Asbestos include:

- Ease of incorporation
- Reduced dust
- Clear, colorless products at low loadings
- Long term shelf life

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COMPARATIVE PERFORMANCE CHARACTERISTICS OF *CALIDRIA* R-G 244/POLYESTER RESIN SYSTEMS

SCOPE

The rheological properties imparted by CALIDRIA R-G 244 Asbestos to polyester resin systems have been determined in a number of commercial laminating resins. Comparative evaluations of CALIDRIA R-G 244 versus pyrogenic silica have also confirmed the performance and economic advantages claimed for CALIDRIA R-G 244 Asbestos.

The following commercial polyester resins were used for these evaluations:

Polyester Resin	Manufacturer
"Hetron" 26869	Durez Div. of Hooker Chemicals Corp.
"Hetron" 17	Durez Div. of Hooker Chemicals Corp.
"Hetron" 130	Durez Div. of Hooker Chemicals Corp.
"Hetron" 19	Durez Div. of Hooker Chemicals Corp.
"Paraplex" 43	Rohm and Haas
"Marco" Resin	Marco Chemical Div. of W. R. Grace Co.
"Koplac" 1000-23	Koppers Company, Inc.
"Dion" DR-315	Diamond Alkali Company, Dion Polymer Prods.
Freeman Resin	Freeman Chemical Corporation

TEST PROCEDURE

To establish a sound and reliable basis for relative test comparisons, viscosities of the base resins were equated by the addition of styrene. CALIDRIA R-G 244 was evaluated in the resins at the 0.5, 1.0, 2.0 and 3.0 parts per 100 parts of resin (PHR). A commercial pyrogenic silica was used for comparative evaluations in several of the resins. Solids were incorporated by one of two procedures:

1. A high-shear laboratory "Homo-Mixer", with a 4-blade, 2-inch diameter impeller.
2. A low-shear "Lightnin' " Mixer, with a 6-paddle, 2-inch diameter impeller.

The degree of shear, implied herein, is in relative terms of impeller rpm. Mixing time was held constant at 3 minutes for all samples.

Viscosity measurements were obtained with a Brookfield Viscometer at 25°C. The samples were hand-stirred prior to measuring the viscosities.

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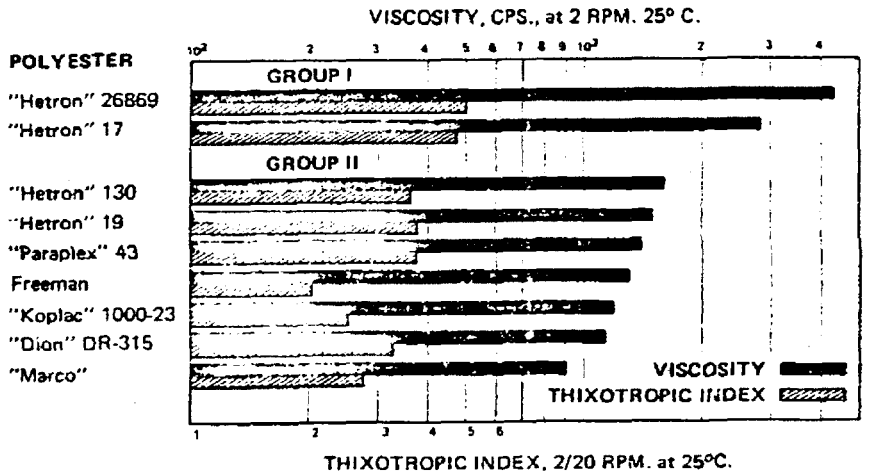
COMPARATIVE PERFORMANCE CHARACTERISTICS OF *CALIDRIA* R-G 244/POLYESTER RESIN SYSTEMS

PERFORMANCE CHARACTERISTICS

The comparative rheological properties of these commercial polyester resins containing CALIDRIA R-G 244 Asbestos are shown in the bar graph, Figure 1. Viscosities are those determined at 2 rpm. Thixotropic Index is based on the 2/20 rpm. viscosities.

FIGURE 1
VISCOSITY AND THIXOTROPIC INDEX DATA

COMPARATIVE PERFORMANCE CHARACTERISTICS OF *CALIDRIA* R-G 244 ASBESTOS IN VARIOUS COMMERCIAL POLYESTER RESINS AT 0.5 PHR ADDITION



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Polyester base resins: adjusted to 100 cps. with styrene.

Mixing: "Lightnin'" Mixer, 6-paddle, 2-inch diameter impeller. Mixed for 3 minutes at 1600 rpm.

PROMOTED POLYESTER RESINS

Unlike most other thixotropes, CALIDRIA R-G 244 does not normally require polar additives such as glycol derivatives for viscosity build-up or thixotropic stabilization. However, in some promoted resins, particularly those containing cobalt-type accelerators, nominal additions of ethylene glycol or similar additives will improve the viscosity, thixotropy, and stability of CALIDRIA R-G 244 dispersions significantly. This is illustrated in Table 1.

TABLE 1
Viscosity of CALIDRIA R-G 244/Promoted Polyester (*) Resin Systems

CALIDRIA R-G 244 (PHR)	Ethylene Glycol (PHR)	Viscosity, cps., at 25°C.		Thixotropic Index at 2 and 20 rpm.
		2 rpm.	20 rpm.	
0.75	— —	800	560	1.4
0.75	0.30	1600	630	2.5

(*) "Silmar Resin" J-3798 — Vistron Corporation
Base viscosity 165 cps.
CALIDRIA R-G 244 incorporated with "Homo-Mixer" at 5000 rpm. for 3 minutes

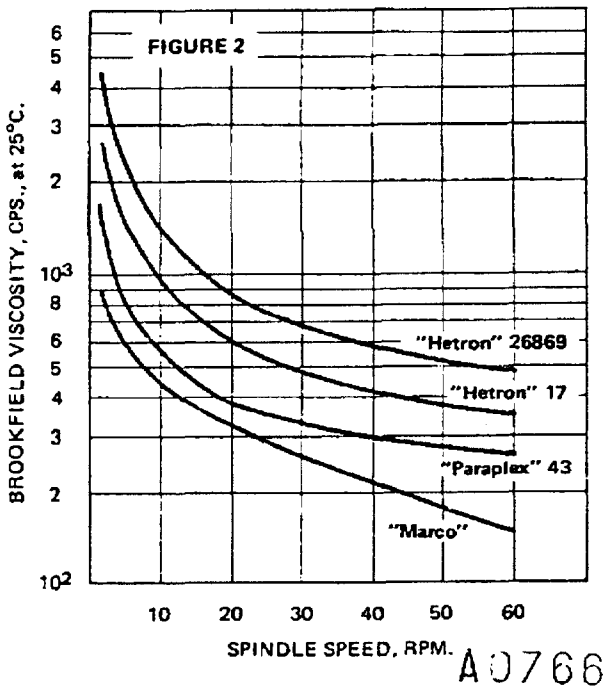
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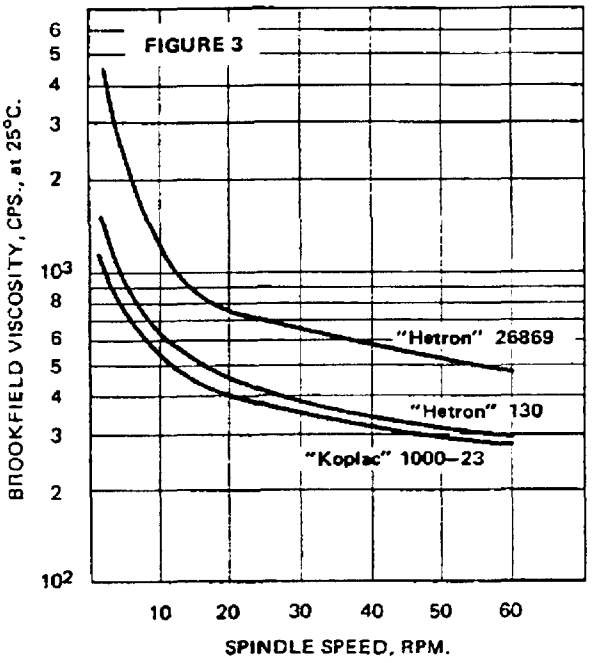
RELATIVE VISCOSITIES

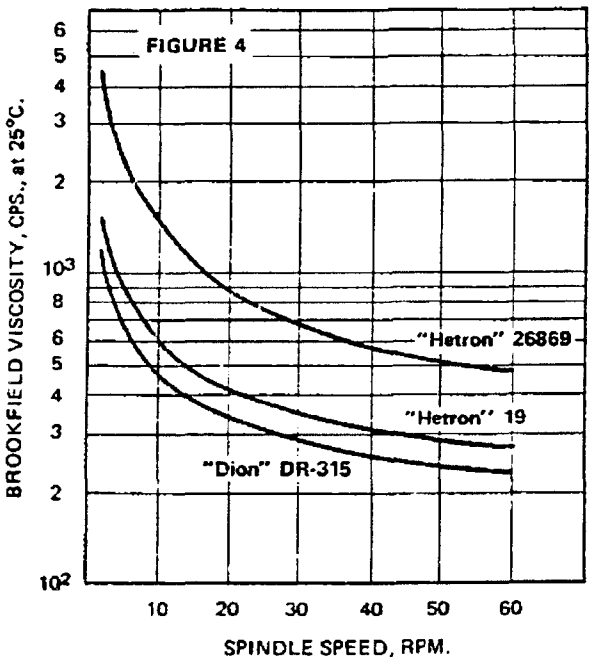
Figures 2 through 5 compare the relative viscosities of the various polyester resins over a range of 2 to 60 rpm.; each containing 0.5 PHR of CALIDRIA R-G 244 Asbestos. "Hetron" 26869 is used as the standard for comparison.

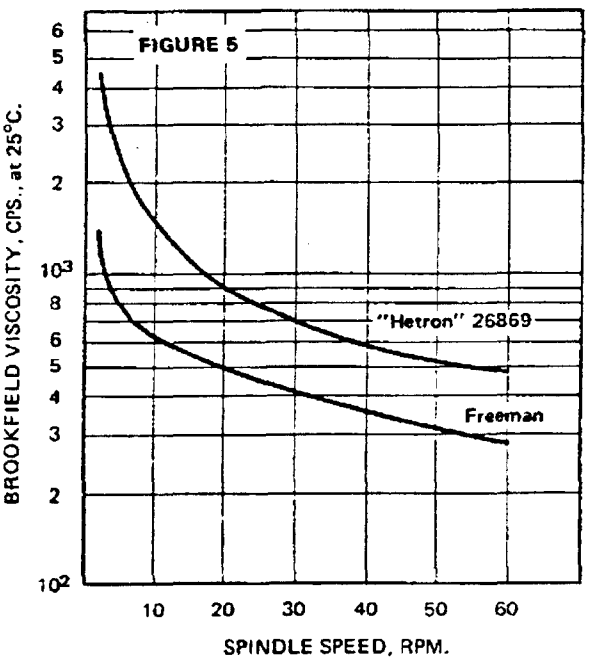
FIGURES 2 THROUGH 5 – COMPARISON OF RELATIVE VISCOSITIES



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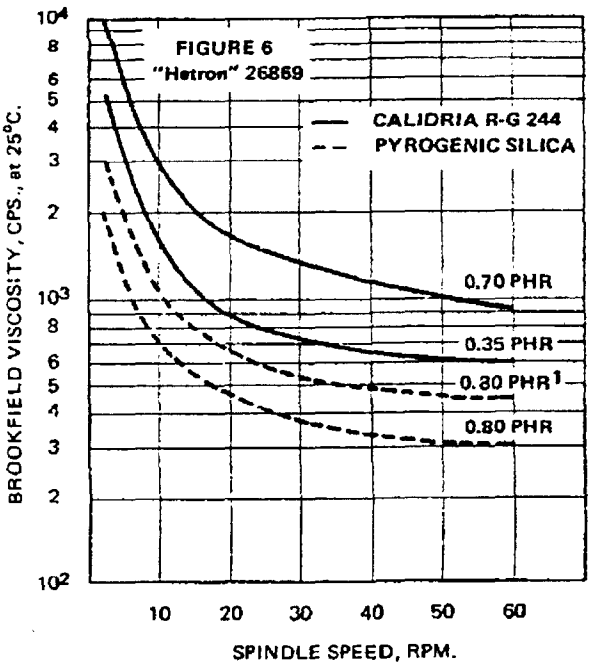
COMPARATIVE PERFORMANCE CHARACTERISTICS OF *CALIDRIA* R-G 244/POLYESTER RESIN SYSTEMS

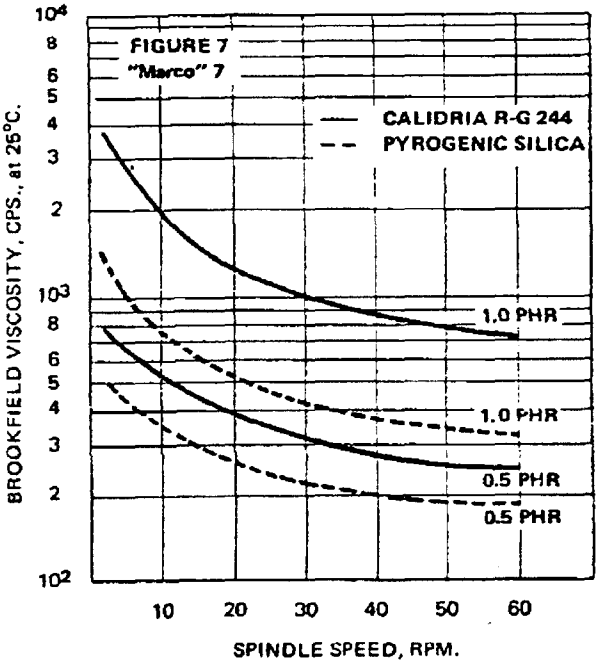
CALIDRIA R-G 244 ASBESTOS VS. PYROGENIC SILICA

A comparison of the relative performances of CALIDRIA R-G 244 Asbestos and pyrogenic silica is shown in Figures 6 through 9. The thickeners were incorporated with a high shear "Homo-Mixer", for 3 minutes, at 5000 rpm. Four polyester resins, ranging from high to medium low performance (see Figure 1, page 4), were selected for this comparative evaluation. In all resins, the performance of CALIDRIA R-G 244 Asbestos was superior to pyrogenic silica for promoting viscosity and thixotropy. In addition, significant economic advantages became apparent.

FIGURES 6 AND 7

COMPARISON OF RELATIVE PERFORMANCES OF *CALIDRIA* R-G 244 AND PYROGENIC SILICA WITH "Hetron" 26869 AND "Marco" 7





NOTE:
Polyester resins were initially adjusted to a Brookfield viscosity of 100 cps. with styrene.
Mixing: "Homo-Mixer" at 5000 rpm. for 3 minutes.

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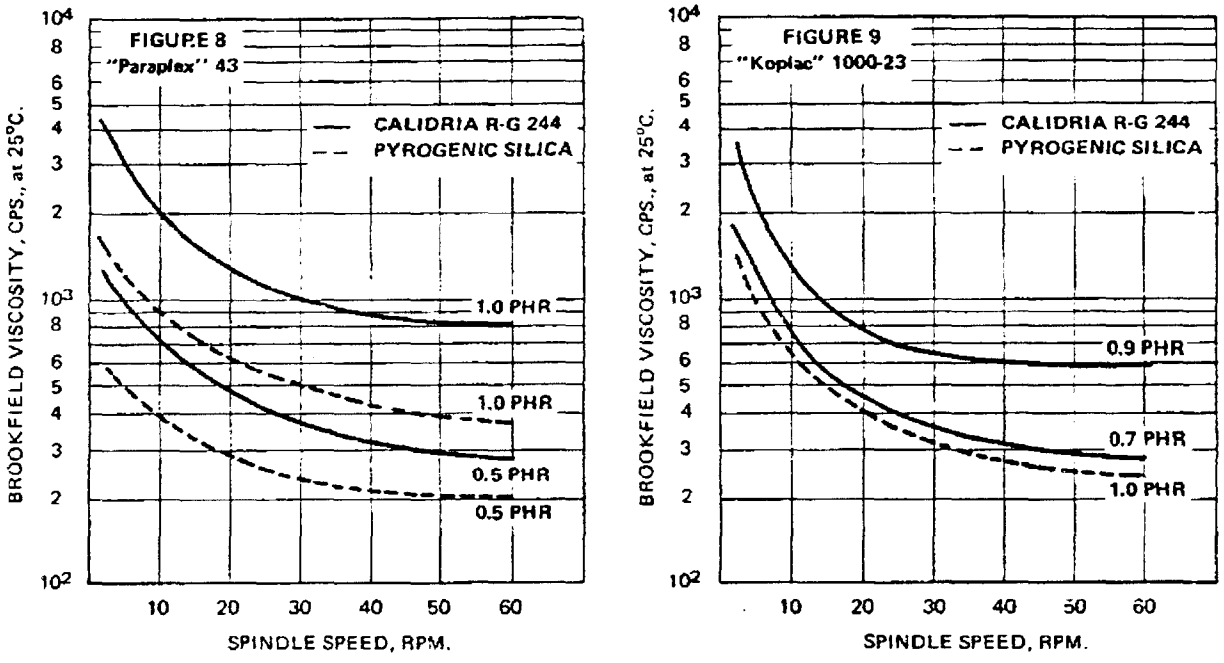
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COMPARATIVE PERFORMANCE CHARACTERISTICS OF *CALIDRIA* R-G 244/POLYESTER RESIN SYSTEMS

FIGURES 8 AND 9

COMPARISON OF RELATIVE PERFORMANCES OF *CALIDRIA* R-G 244 AND PYROGENIC SILICA WITH "Paraplex" 43 AND "Koplac" 1000-23



NOTE:

Polyester resins were initially adjusted to a Brookfield viscosity of 100 cps. with styrene.

Mixing: "Homo-Mixer" at 5000 rpm. for 3 minutes.

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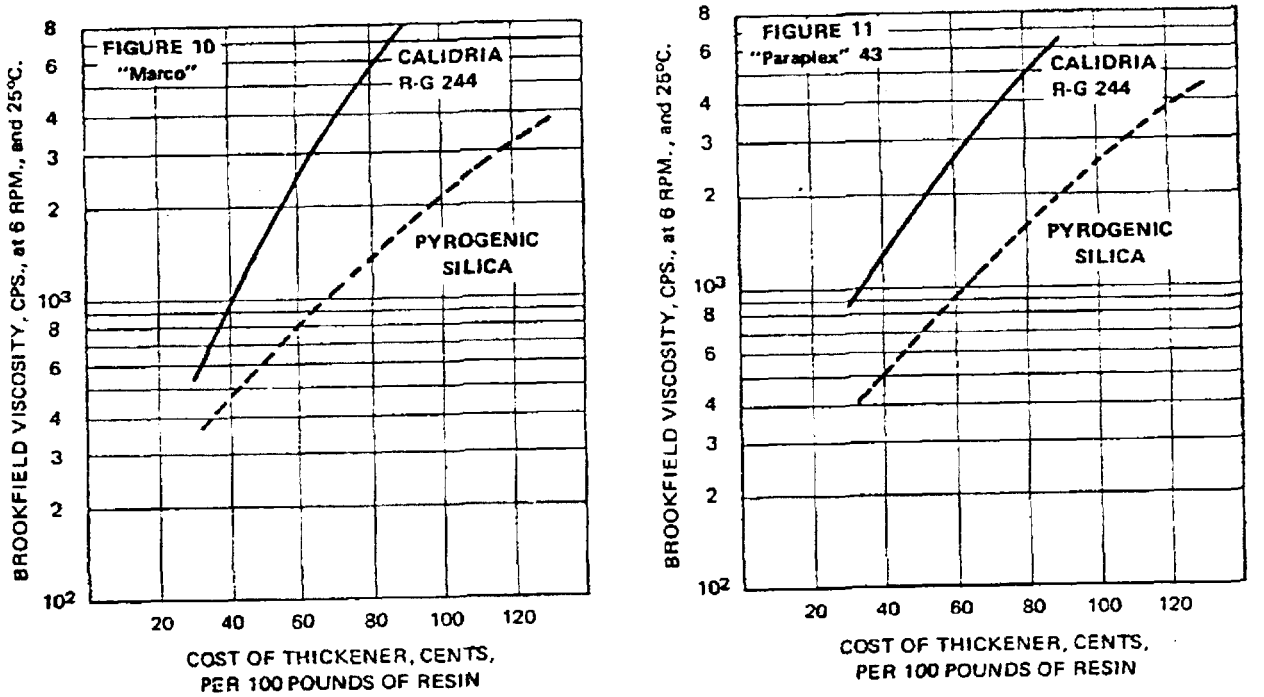
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VISCOSITY VS. COST

Figures 10 and 11 compare the viscosities obtained at 6 rpm., on various additive concentrations vs. the relative cost of the thickeners per 100 pounds of the polyester base resins. From these comparative tests and the relative thixotropic properties shown in Figure 16, page 11, it can be concluded that CALIDRIA Resin-Grade 244 Asbestos will provide, on the average, viscosities equivalent to pyrogenic silica, at approximately one-half the cost.

FIGURES 10 AND 11

COMPARISON OF VISCOSITIES VS. RELATIVE COST OF THICKENERS



SHEAR EFFECTS ON RHEOLOGICAL PROPERTIES

The effects of shear on the rheological properties of CALIDRIA R-G 244 Asbestos and pyrogenic silica in polyesters are shown in Figures 12 to 15. "Paraplex" 43 and "Marco" resins, considered to be typical of most polyester systems, were selected for these tests. Although results obtained with laboratory equipment cannot be assumed to predict optimum conditions for production facilities, these data do indicate that pyrogenic silica is more shear dependent than CALIDRIA R-G 244. On this basis, it can be concluded that pyrogenic silica requires relatively higher levels of energy to develop optimum rheological properties, in polymer suspensions, equivalent to those obtainable with CALIDRIA R-G 244 Asbestos.

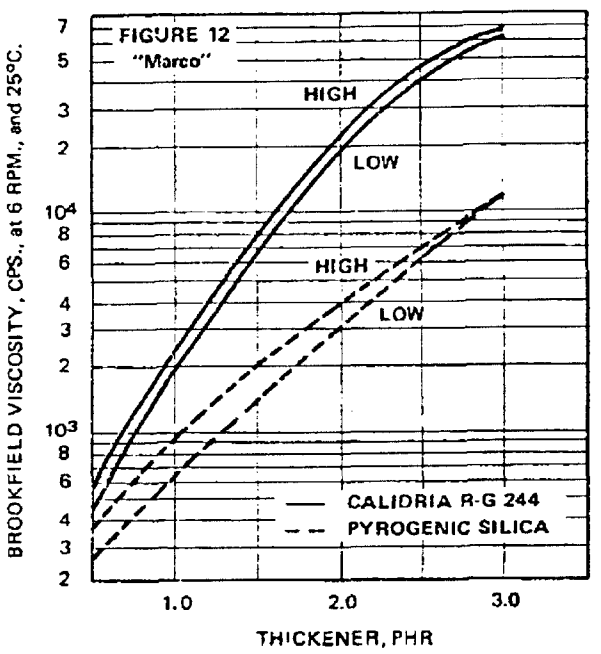
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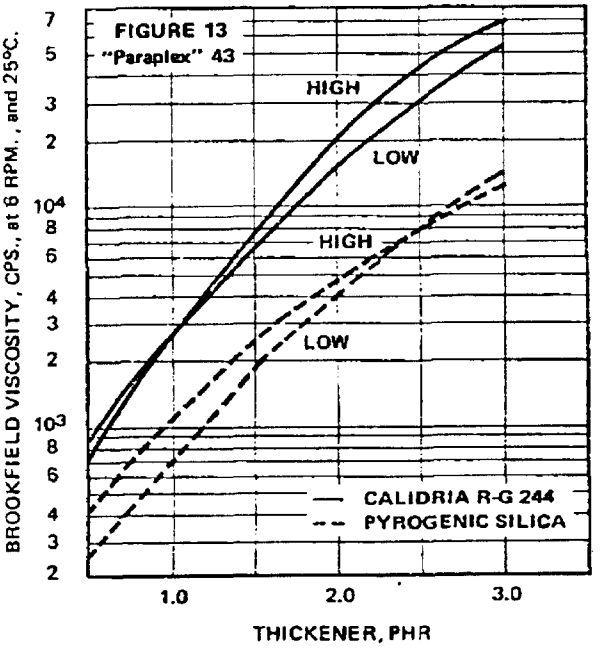
HIGH AND LOW SHEAR MIXING VS. SOLIDS CONTENT

The viscosity vs. solids content experimental results shown in Figures 12 and 13 below were obtained with both high and low shear mixing equipment, using the following standard testing conditions. The initial viscosity of each of the polyester base resins was adjusted to 100 cps. with styrene.

	High-Shear "Homo-Mixer"	Low-Shear "Lightnin' " Mixer
Mixing Time, minutes	3	3
Mixing Blades and Size	4 - 2-inch diameter	6 (paddle) - 2-inch diameter
Mixing Speed, rpm.	5000	1600 (tip speed 800 to 900 rpm.)

FIGURES 12 AND 13
VISCOSITY VS. THICKENER CONCENTRATION
RELATIVE EFFECT OF HIGH AND LOW SHEAR MIXING





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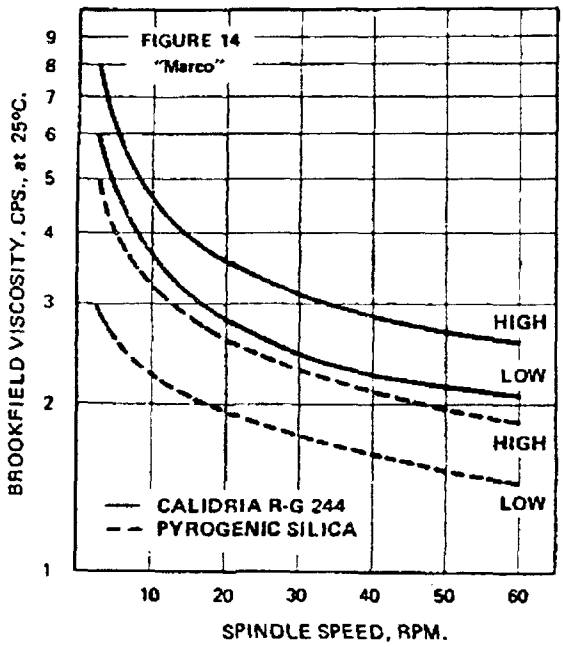
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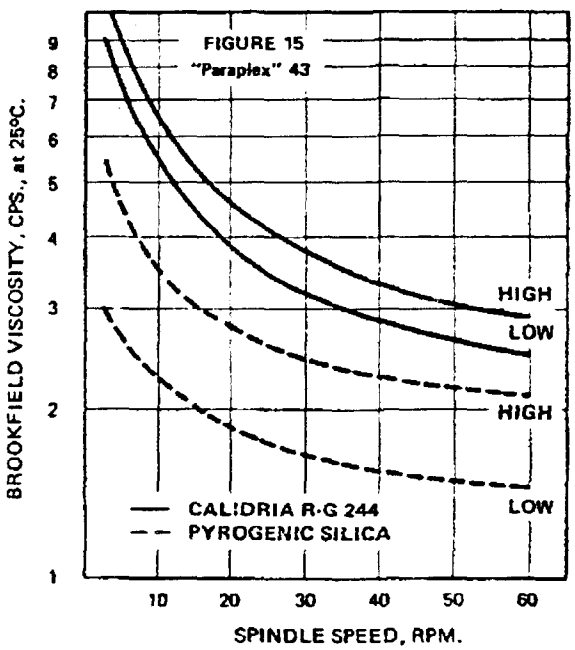
VISCOSITY VS. SHEAR RATE

Viscosities determined at 25°C., over a range of spindle speeds, from 2 to 60 rpm, on "Marco" and "Paraplex" 43 polyesters, containing 0.5 PHR of the thickeners, indicate that CALIDRIA R-G 244 Asbestos, again, maintains a relatively higher degree of thickening efficiency than pyrogenic silica, Figures 14 and 15.

It is evident from these results that pyrogenic silica is more shear dependent than CALIDRIA R-G 244 Asbestos and requires higher levels of energy to develop satisfactory rheological properties for polymer suspensions.

FIGURES 14 AND 15
VISCOSITIES AT VARIOUS SHEAR RATES
VS. EFFECT OF HIGH AND LOW SHEAR MIXING
OF POLYESTERS CONTAINING 0.5 PHR OF THICKENERS





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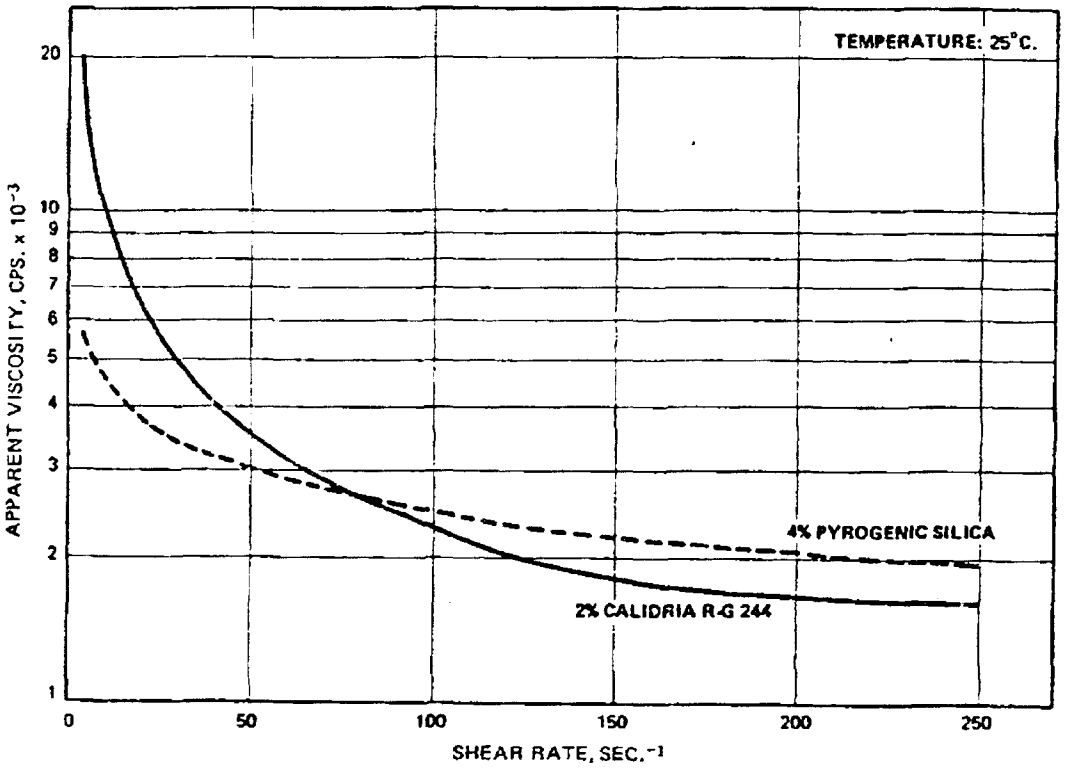
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EFFECT OF SHEAR RATE ON THIXOTROPIC PROPERTIES

CALIDRIA R-G 244 Asbestos provides exceptional rheological characteristics to polyester resins as shown in Figure 16. As indicated, a more fluid system for better spraying and brushing performance is available at one-half the concentration using CALIDRIA R-G 244 as compared to pyrogenic silica, yet sag resistance and viscosity are higher as the shear rate is reduced.

FIGURE 16
COMPARATIVE THIXOTROPIC CHARACTERISTICS
CALIDRIA R-G 244 VS. PYROGENIC SILICA



NOTE:
These data were developed for a "Paraplex" 43 polyester resin (Rohm and Haas) with 10 per cent by weight of styrene added. Instrumentation was with a Haake "Rotovisco", using measuring system SV II.

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