ENCLOSED WITH: 2-6-62

FROM: ..... TO .....

SHELL CHEMICAL COMPANY
A DIVISION OF SHELL OIL COMPANY
UNION TECHNICAL SERVICE LABORATORY
UNION, NEW JERSEY

UTSL Report No. PP-SD-1009-9

EPON® Resin Polyamide Coating For Marine Splash Zone Use

by

R. A. Allen

February 6, 1962

ABSTRACT

Formulation variables of two EPON® Resin polyamide coating compositions designed for underwater applications to marine structures were studied. These were developed by Mr. R. M. Jorda of Shell Development, Houston, and are designated as Type "A" and Type "B".

The variables studies were the percentage excess (over stoichiometric quantity) of polyamide, the type of polyamide used and the pigmentation of the system. The various modifications, applied under water to sandblasted pipe, were evaluated after three months in salt spray and brine immersion.

The best overall performance at a minimum raw material cost was obtained from our modification of the Type "B" formulation containing EPON Resin 828 and Versamid 125 (16% excess polyamide) in which silica was the principal inert.

Commercially manufactured samples of both Type "A" and "B" Jorda formulations were also evaluated against one another and against laboratory control batches of the same formulations prepared at UTSL. All the commercially prepared coatings were rated excellent for substrate protection, salt water immersion, and salt spray environment although they did differ in sagging properties.

Table of Contents

SUMMARY

Two polyamide cured EPON® Resin formulations were developed by Mr. R. M. Jorda of Shell Development, Houston and designated Type "A" and Type"B"respectively. They are both two-package systems similar to caulking compounds in consistency. These compositions can be applied manually underwater and were specifically developed for protecting offshore structures such as drilling rigs from splash zone corrosion.

A limited study of the formulation variables of Formula "A" and Formula "B" compositions was undertaken at UTSL. We investigated a range of polyamide to EPON Resin ratios, some different types of polyamides and the effect of variation of pigment type and pigment loading.

It was found that the polyamide content could be varied through a wide range (0% to 150% excess over stoichiometric quantity) without adversely affecting the protective properties of the coating. Adhesion decreased with increasing polyamide content, while the cured coating ranged from hard and slightly brittle at 0% excess to soft and spongy at 150% excess. An optimum combination of adhesion and toughness was achieved at about 15-25% polyamide excess.

High pigment loading at reasonable working consistency could be obtained with silica (SiO_2) as the principal inert pigment. A modification of the basic Type "B" formulation based on Versamid 125 and EPON Resin 828 with 16% polyamide excess was particularly promising at a high silica loading. This formulation mixed and applied well and exhibited excellent adhesion and substrate protection. In addition, the raw material cost of the formulation was reduced 30%.

Pittsburgh Plate Glass Company, Cook Paint and Varnish Company, and Napco Corporation submitted samples of both Type "A" and Type "B" formulations. We evaluated these against one another and against laboratory control batches of the same formulations prepared at UTSL.

All the Type "A" formulations were found to be essentially equal in performance. Of the Type "B" formulations, the Cook Paint and Varnish Company and the Napco Corporation samples sagged more than the laboratory prepared control samples, while the Pittsburgh Plate Glass Company's version was superior to the control samples in this property. However, all the commercially prepared coatings were rated excellent for substrate protection in salt water immersion and salt spray environment.

INTRODUCTION

Mr. R. M. Jorda of Shell Development, Houston, Texas, has developed and field tested two EPON Resin polyamide formulations identified as Type "A" and Type "B" for arresting splash zone corrosion on existing offshore structures.

Note: The term splash zone refers to the area of an offshore marine structure (such as an oil drilling rig) which is located between the low and high tide levels and is subject alternately to wetting with salt water and exposure to air. Because of these conditions, the corrosion rate of the metal structural members is very high in this particular area

This type of coating has the very great advantage that it can be applied to wet surfaces even in turbulent water. This is thought to be due to preferential wetting of the metal surface by the polyamide resin. The coating cures above and below the water line to a hard, corrosion resistant plastic barrier, affording maximum protection. Field tests showed this coating to be effectively preventing corrosion after eight months service.

In actual use the EPON Resin component and polyamide component are mixed just prior to application. The two components are pigmented in contrasting colors, in our work, blue and yellow. Mixing is considered complete when the mixture is a uniform green color. The mixture is similar to caulking compound in consistency, although somewhat more viscous, and has a working pot life of from one to one and a half hours.

Although the two Jorda compositions were shown to be effectively arresting splash zone corrosion in actual field tests, he made no attempt to optimize application properties or formulation costs at this stage of his development work.

Within this general framework, UTSL was requested to undertake a limited laboratory program directed toward obtaining the following general information on the Type "A" and Type "B" formulations:

1. The effect of varying the excess polyamide resin
2. The effect of the type of polyamide resin used
3. The effect of different types and levels of extender pigment
4. Optimizing formulation raw material costs.

In addition, commercial samples of both Type "A" and "B" formulations prepared for us by different paint companies were to be compared against one another and against laboratory preparations as control materials.

The general evaluation procedure employed for determining the suitability of this type of coating material is outlined in the Experimental Section.

EXPERIMENTAL

1. Preparation of Components

EPON Resin Component

The EPON Resin and stabilized Mod-Epox[1] were charged into a pony mixer. The extender pigment and covering pigment were added and stirring continued until a smooth paste was obtained. The paste was then given one "loose" pass on a three roll mill.

1. Stabilized Mod-Epox is prepared separately by mixing in Magnesium Oxide, 1% based on the Mod-Epox. This mixture is then incorporated in the formulation.

Polyamide Resin Component

The polyamide resin was mixed with the extenders and pigment in the same manner as was the EPON® Resin. This paste was also given a "loose" pass on a three roll mill.

2. Mixing of EPON Resin/Polyamide Coating Prior to Application

The two components were mixed in exact proportions by weight. The proportions actually used depended upon the pigment content and/or the EPON Resin to polyamide curing agent ratio desired in the formulation in question.

Since the two components are pigmented in contrasting colors, adequate mixing can be determined visually as the point at which a uniform color is obtained.

3. Application of Coating

The mixed composition was applied under 3% brine solution to 8 inch lengths of 1 inch sandblasted steel pipe. The application method recommended by Mr. Jorda[1)] was used. This application procedure was as follows:

The entire surface of the pipe was wetted with brine solution, and the pipe was held vertically in a beaker of 3% brine. A doughnut-shaped ring of the compound was formed above the water line. The material was then smeared down uniformly below the water level, at a thickness of 1/8 to 1/4 of an inch. The application is completed by feathering the top and bottom edges of the coating to the pipe.

Two pieces of pipe were sandblasted and coated, under 3% brine, with each formulation.

4. Laboratory Test Procedures

One pipe was allowed to remain in a 16 oz. olive jar with the lower half of the coated surface immersed in 3% brine solution. In this test the water evaporation was replaced daily, and the brine solution changed at two week intervals.

The second pipe after being allowed to set in 3% brine solution overnight was placed upright in the salt spray cabinet in a suitable rack. Corks were placed in both ends of each pipe to prevent rusting from the inside.

1. EPR Report 581, October 1960, Page 7, Figure 14, entitled "Protecting of Existing Offshore Structures Against Splash Zone Corrosion with EPON Polyamide" by R. M. Jorda.

The test procedures adopted in this work were employed by Mr. Jorda in his original evaluation program. They were found equally effective as a screening method in simulating splash zone coating procedure described in his EPR Report 581 of October, 1960.

5. Evaluation of Coatings

The following properties associated with application were observed for the various formula modifications:

Ease of mixing of EPON Resin component with the polyamide component
Ease of application to the wet surface of the substrate
Resistance to sagging
Working pot life

After three months exposure to salt spray and brine immersion, the pipes were examined by cutting away a section of the coating to reveal the condition of the substrate. The coatings were then evaluated for the following characteristics.

Protection of substrate
Adhesion of the coating to the substrate
Physical nature of the coating

6. Storage Stability of the EPON Resin Component and Polyamide Resin Component.

Closed containers of the various components were examined after standing for three months at 75°F-90°F for any marked changes in consistency.

RESULTS AND DISCUSSION

I. Jorda Formulations - Types "A" and "B"

1. Characterization and Evaluation

Two formulations were given in the EPR Report 581, October 1960, entitled "Protecting of Existing Offshore Structures Against Splash Zone Corrosion with EPON Polyamide" by Mr. Jorda. These formulations were designated Type "A" and Type "B" and are described in Table 1.

When mixed in the designated proportions, and applied underwater to sections of sandblasted 1 inch pipe, the following observations were made:

Formulation A

Thorough mixing of this formulation was somewhat impeded by the fact that the polyamide component was much more viscous than the EPON Resin component. The polyamide component tended to slide around in lumps in the EPON Resin phase. This necessitated a great deal of extra stirring to insure thorough mixing. However, when thoroughly mixed, the material applied well and did not sag.

Formulation B

The two components of this formulation were of similar consistency, and mixed smoothly and easily. This material applied well, but showed a tendency to sag.

From our observation of the application characteristics of the two materials, it was evident that although there was a wide difference in excess of polyamide, both formulations applied well underwater. It appeared that the preferential wetting effect of the polyamide was operative in both cases.

Both the Type "A" and Type "B" formulations have been field tested by Mr. Jorda and shown to be effective as protective coatings. Our work involved the modification of these formulations to optimize working properties, corrosion resistance properties, and cost.

II. UTSL Formulation Modifications

1. The Effect of Varying Excess Polyamide Resin

The Versamid resins used in these coatings are essentially amine terminated polyamides formed by reacting fatty acid dimers and diamines. As amines and amides are known for their preferential bonding ability over water on metal surfaces, a definite excess of polyamide resin over the stoichiometric amount required to cure the EPON Resin was considered necessary.

To determine the effect of this excess on the properties of the coating, we varied the excess of the polyamide resin over stoichiometry in both the Type "A" and Type "B" formulations from 0% (exact combining weights of each material) to 150% (two and one-half combining weights of polyamide to each combining weight of epoxy resin). These compositions were then applied underwater to sandblasted 1 inch steel pipe. This series of experiments is listed in Tables 2 and 3.

It was found that Type "A" formulation applied well at all levels of polyamide concentration, while Type "B" formulation showed moderate sagging when no excess was used, and somewhat more sagging at the recommended excess of 16%. At higher levels of polyamide resin, the sagging was severe

enough to prevent satisfactory coating of the pipes. This sagging tendency was controlled, however, by using an extender combination of mineral filler and barytes, in place of the talc/barytes combination in the original Type "B" formulation. A series of coated pipes were prepared using this modified Type "B" formulation at levels of polyamide excess ranging from 0% to 150%.

In general, the physical characteristics of the coatings ranged from hard, almost brittle, at 0% excess to soft and spongy at 150% excess polyamide resin. This is due to the plasticizing effect of the polyamide resin itself.

It was also noted that the adhesion of the cured coating decreased as the excess of polyamide resin was raised. The protection of the substrate in both salt spray and brine immersion was excellent throughout the series. In this type of application, it appears that the ratio of polyamide resin to EPON Resin is not highly critical. However, there appears to be a satisfactory compromise between adhesion and toughness that becomes evident between 15% and 50% excess.

We have prepared modified Type "A" and Type "B" formulations at 25% and 16% excess polyamide resin respectively and found them to possess excellent application and substrate protection properties.

2. The Effect of Changing the Polyamide Resin Type

In order to lower the viscosity of the polyamide phase of the Type "A" formulation, and thereby improve ease of mixing, a series of low viscosity polyamide resins were substituted for the Versamid 125/ Versamid 115 blend.

These materials were, in order of decreasing viscosity; Versamid 140, a three to one blend of Versamid 125 and Genamid 250, and a one to one blend of Versamid 125 and Genamid 250. Genamid 250 is a very low viscosity material. It has a viscosity of 5-10 poises at room temperature as compared with greater than 100 poises for the Versamid 125 and Versamid 140. The incorporation of the Genamid 250 made it possible to increase the inert pigment loading of the polyamide component while maintaining satisfactory mixing characteristics.

Formulations containing the three polyamide materials listed above were prepared at the recommended polyamide excess for the Type "A" formulation, namely 136%. We also prepared a formulation containing a three to one blend of Versamid 125 and Genamid 250 at 25% excess, because some preliminary exposure tests, run for one month, indicated that an optimum between toughness and adhesion existed at this level. As this series was quite low in cost, as a result of high pigment loading, the formulation with 25% excess polyamide resin represented an optimum in film characteristics and raw material cost.

These formulations are listed in Table 4. The ease of mixing was found to be improved by using the lower viscosity polyamide materials.

The application of these materials underwater was satisfactory, although there appeared to be somewhat more leaching out (evidenced by "clouding up" of the brine solution during coating) with the low viscosity polyamide resins than with the higher viscosity materials.

It is our feeling that this tendency might be troublesome in moving water. That is, an excessive amount of polyamide might be leached from the compound, resulting in insufficient curing agent in the other surface of the coating.

After the three months' exposure tests were completed, all modifications containing 136% excess polyamide resin showed a strong tendency to absorb water on immersion to the extent that it was actually visible when the cured coating was freshly cut. The adhesion was also quite poor, as the coating could be easily peeled from the substrate. This poor performance appears to be due to a combination of the greater water sensitivity of the low viscosity polyamide resins, and the high polyamide excess recommended in the Type "A" formulation. This is borne out by the fact that the formulation with a polyamide resin excess of 25% showed excellent adhesion and no water sensitivity. (Table 4, Combination 4) Further, the original Type "A" formulation with 136% excess high viscosity polyamide resin was given a fair rating in adhesion, and did not appear to have the water sensitivity of the low viscosity materials.

3. Low-Cost-High Extender Modifications

The original Type "A" formulation contains an extender combination of aluminum powder and asbestos pigment. The Type "B" formulation contained talc and barytes. In our modifications of these formulations we did not include the aluminum powder primarily because it is rather expensive ($0.20 per pound) as compared with other fillers ($0.03 to $0.05 per pound).

The original formulation also contained as color pigment, phthalocyanine blue and chrome yellow. As the phthalocyanine blue is quite expensive (about $3.00 per pound) we replaced it with iron blue ($0.57 per pound) in one case and lamp black ($0.28 per pound) in another. These colors were satisfactory for achieving contrast (to denote adequate mixing) and did not detract from the other properties of the system. Although we did not make a substitution for the chrome yellow ($0.35 per pound) a replacement by iron oxide yellow is indicated, as it is cheaper ($0.12 per pound) and generally more stable.

Talc, asbestos, barytes and silica are the principal types of extender pigments which combine low cost with chemical inertness. Two other extender pigments which are widely used in coatings are calcium carbonate and china clay (aluminum silicate). Calcium carbonate was not used in our laboratory program because it is not chemically inert, being readily decomposed by acids. China clay is reactive with the epoxide groups contained in the EPON Resins giving an unstable compound and therefore was omitted from these experiments. Our investigation was confined to determining what combinations and concentrations of inerts to use in EPON Resin/polyamide resin formulations to achieve an optimum balance in mixing ease, nonsagging properties, substrate protection and raw material costs.

Talc and asbestos filler are similar chemically, both being magnesium silicates. The asbestos filler, however, imparts nonsagging properties to a formulation. It also contributes a cohesiveness that we feel in desirable in such a composition to withstand wave action (turbulent water) while it is curing in the splash zone.

Magnesium silicates are generally used in combination with barytes or some other extender pigment, as coatings extended with magnesium silicate alone often lack toughness and film integrity. Another extender pigment which is widely used as a filler for epoxy systems is silica. We incorporated a small amount of asbestos filler to control sagging with this extender.

Preliminary experiments had shown that asbestos filler and barytes was an effective combination, so was silica and asbestos filler. As these coating compositions must be mixed at the application site, possibly by hand, the degree of pigment loading is limited by the increase in consistency which would be imparted to the formulation. This critical concentration has to be established empirically for each EPON Resin/polyamide resin composition under study. Holding this optimum pigment concentration constant, the degree of film flow or nonsagging characteristic desired is now obtained by simply varying the ratio of asbestos filler to the other extender of the combination.

Other preliminary work, consisting of one month's salt spray exposure and brine immersion, indicated that the optimum range of polyamide resin excess was in the range of 16% to 50% for optimizing general film properties. With this information to go on, raw material cost was optimized by increasing the pigment loading of a composition in this range to a maximum while maintaining good mixing characteristics.

High extender pigment modified Types "A" and "B" formulations appearing in Table 5 represent combinations of asbestos filler/barytes and silica/asbestos filler at the ratios and total concentration consistant with the findings discussed above. In addition both of these compositions optimize combinations of mixing ease, nonsagging properties, substrate protection and formulation costs.

4. Evaluation of Commercially Prepared Formulations

We were requested to evaluate commercially manufactured samples of the original Type "A" and Type "B" formulations made for us by the following paint companies:

Pittsburgh Plate Glass Company	Houston, Texas
Napco Corporation	Houston, Texas
Cook Paint and Varnish Company	Houston, Texas

Both Type "A" and Type "B" formulations from Napco Corporation and Pittsburgh Plate Glass Company were tested. Only the "B" formulation from Cook Paint and Varnish Company was evaluated due to an insufficient quantity of the Type "A" formulation received. The results of this evaluation are listed in Table 6.

In the application and exposure tests, the Type "A" formulations were found to be essentially equal to the control (prepared at UTSL) in performance. Of the Type"B" formulations, the Cook and Napco samples sagged somewhat more than the control, while the Pittsburgh version was superior to the control in this property. This appears to be due to the selection of fine "stir in" grades of talc by Cook and Napco. These types of talc do not prevent sagging as effectively as the coarser material used by Pittsburgh in this formulation. The excessive sagging made the Cook and Napco compositions difficult to apply. In addition, these coatings did not adhere as well as the Pittsburgh Plate Glass Company formulation or the UTSL control. However, all the commercially prepared coatings were rated excellent for substrate protection.

The consistency of all uncatalyzed base formulations appeared essentially unchanged after three months' storage at 75-90°F. The workable pot life of the catalyzed systems were all about the same.

CONCLUSIONS

Based on this limited laboratory investigation, several conclusions may be drawn:

1. Large increases in excess polyamide resin over the stoichiometric amount is accompanied by an increase in softness and a lessening of adhesion. The optimum polyamide resin excess appears to be about 15% to 25%.

2. Genamid 250, a low viscosity polyamide resin can be used to optimize pigment loading at workable consistencies providing a very large excess of polyamide resin over the stoichiometric amount is not used.

3. Asbestos filler/barytes and silica/asbestos filler are both effective extender combinations for use in EPON Resin/polyamide compositions. All else being equal, silica in combination with a small percentage of asbestos filler allows the greatest degree of pigment loading with satisfactory mixing consistency.

4. Increased extender pigment loading offers an effective means of lowering formulation costs.

RECOMMENDATIONS

The two low cost formulations in Table IV are both candidates for recommendation, but we favor the high extender Type "B" formulation because the Versamid 125, EPON Resin mixture in this formulation does not show the leaching tendency exhibited by the high inert Type "A" formulation.

Samples of the high extender Type "B" formulation were submitted to Mr. Jorda for his evaluation. He reported it satisfactory in all respects.

REFERENCES

Technical Record Book, Volume 960, Pages 21-37 inclusive
and 57-61 inclusive

PARTICIPANTS IN WORK REPORTED

R. A. Allen, E. M. Friedman

R. A. Allen

J. P. Manasia

G. R. Somerville

C. M. Reider

Appendix

Table 1

Description of Jorda Formulations

Type "A"				Type "B"			
EPON Resin Component	%wt.	Polyamide Resin Component	%wt.	EPON Resin Component	%wt.	Polyamide Resin Component	%wt.
EPON 815	48.8	Versamid 115	35.7	EPON 828	46.3	Versamid 125	79.2
Mod-Epox	9.9	Versamid 125	35.7	Mod-Epox	4.6	Barytes 89	9.9
Aluminum Powder	18.2	Aluminum Powder	11.9	Talc 1767	46.3	Talc 1767	9.9
Mineral Filler 1719	18.2	Mineral Filler 1719	11.9	Med. Chrome Yellow	2.8	Phthalo Blue	1.0
Phthalo Blue	4.9	Med. Chrome Yellow	4.8		100.0		100.0
	100.0		100.0				

Parts by weight of Polyamide Resin component per 100 parts of EPON Resin Component	188.8	67.8
Pigment to Binder Ratio	0.5/1.0	0.6/1.0
Excess Polyamide Resin over the stoichiometric amount	136%	16%

Table 2

The Effect of Varying the Polyamide Resin Excess in the Type "A" Formulation

EPON Resin Component	%wt.	Polyamide Resin Component	%wt.
EPON 815	48.8	Versamid 125[5]	35.7
Mod-Epox[1]	9.9	Versamid 115[5]	35.7
Aluminum Powder #201[2]	18.2	Aluminum Powder #201	23.8
Asbestos Filler (Mineral Filler 1719[3])	18.2	Medium Chrome Yellow Y469-D[4]	4.8
Phthalocyanine Blue #284D	4.9		100.0
	100.0		

Parts by Weight of Polyamide Resin Component per 100 parts of EPON Resin Component	80.5	121.0	161.0	188.8	201.0
Percent Excess Polyamide Resin over Stoichiometric Amount	0%	50%	100%	136%	150%
Evaluation of:					
1. Application Variables					
Mixing Ease	Fair-Poor	Fair-Poor	Fair-Poor	Fair-Poor	Fair-Poor
Degree of Sagging	None	Slight	Slight	Slight	Slight
Pot life (hours)	1-1.5	1-1.5	1-1.5	1-1.5	1-1.5
2. Coating Performance After Three Months' Exposure					
Protection of Substrate in Salt Spray Environment	Good*	Exc.	Exc.	Exc.	Exc.
Protection of Substrate Immersed in 3% Brine	Exc.	Exc.	Exc.	Exc.	Exc.
Adhesion (both test media)	Good	Good	Good-Fair	Fair	Fair
Characteristics of Film (both test media)	Hard, Tough	Hard, Rubbery	Hard, Rubbery	Spongy, Rubbery	Spongy, Soft

*Rust specks under thin part of feathered edge.

1. Monsanto Chemical Company
2. Metals Disintegrating Company, Inc.
3. Wittaker, Clark and Daniels
4. I. E. duPont deNemours and Company, Inc.
5. General Mills Inc.

Table 3

The Effect of Varying the Polyamide Excess in the Type "B" Formulation

EPON Resin Component	Original Formulation %wt.	Formulation Modified to Prevent Sagging %wt.
EPON 828	46.3	45.4
Mod-Epox[1]	4.6	4.5
Talc 1767[2]	46.4	
Asbestos Filler (Mineral Filler 1719)[2]	-	20.0
Barytes 89[2]	-	20.0
Medium Chrome Yellow Y469D[3]	2.7	10.1
	100.0	100.0
Polyamide Resin Component	**%wt.**	**%wt.**
Versamid 125[4]	79.2	53.9
Talc 1767	9.9	
Asbestos Filler (Mineral Filler 1719)		22.7
Barytes 89	9.9	22.7
Phthalocyanine Blue #284D[3]	1.0	0.7
	100.0	100.0

Parts by Weight of Polyamide Resin Component per 100 Parts EPON Resin Component	58.5	67.8	83.4	97.6	125.0	167.0	208.0
Percent Excess Polyamide Resin over the Stoichiometric Amount	0%	16%	0%	16%	50%	100%	150%
Evaluation of:							
1. Application Variables							
Mixing Ease	good	good	fair	fair	fair	fair	fair
Degree of Sagging	mod.	mod.-severe	none	none	none	none	none
Pot Life (hours)	1-1.5	1-15.	1-1.5	1-1.5	1-1.5	1-1.5	1-1.5
2. Coating Performance After Three Months' Exposure							
Protection of Substrate in Salt Spray Environment	exc.	exc.	exc.	exc.	exc.	good*	good*
Protection of Substrate immersed in 3% brine	exc.	exc.	exc.	exc.	exc.	exc.	exc.
Adhesion (both test media)	exc.	exc.	exc.	exc.	exc.	good	good
Characteristics of film (both test media)	hard Sl.brittle	hard	hard	hard	hard tough	hard rubbery	hard rubbery

*rust specks under thin part of feathered edge.

1. Monsanto Chemical Company
2. Whittaker, Clark, and Daniels, Inc.
3. E. I. duPont deNemours and Company, Inc.
4. General Mills, Inc.

Table 4

The Effect of Polyamide Resin Type

	Combination 1 %wt.	Combination 2 %wt.	Combination 3 %wt.	Combination %wt.
Polyamide Resin Component				
Versamid 140[1]	43.3	-	-	-
Versamid 125	-	24.6	17.1	24.6
Genamid 250[1]	-	8.2	17.1	8.2
Asbestos Filler (Mineral Filler 1719[2])	26.9	32.5	31.8	32.5
Barytes 89	26.9	32.5	31.8	32.5
Medium Chrome Yellow Y469D[3]	2.9	2.2	2.2	2.2
	100.0	100.0	100.0	100.0
EPON Resin Component				
EPON 815	38.0	34.8	34.8	34.8
Mod-Epox[4]	7.5	7.0	7.0	7.0
Asbestos Filler (Mineral Filler 1719)	25.3	27.4	27.4	28.8
Barytes 89	25.3	27.4	27.4	28.9
Phthalocyanine Blue #284D[3]	3.9	3.4	3.4	Iron blue 0.5
	100.0	100.0	100.0	100.0
Parts by Weight of Polyamide Resin Component per 100 parts of EPON Resin Component	165.0	224.0	196.0	119.0
Percent Excess Polyamide over Stoichiometric Amount	136%	136%	136%	25%
Evaluation of:				
1. Application Variables				
Mixing Ease	Fair to Poor	Fair	Fair	Fair
Degree of Sagging	None	None	None	None
Pot Life (hours)	1-1.5	1-1.5	1-1.5	1-1.5
2. Coating Performance After Three Months' Exposure				
Protection of Substrate in Salt Spray Environment	Excellent	Excellent	Excellent	Excellent
Protection of Substrate immersed in 3% brine	Excellent*	Excellent*	Excellent*	Excellent
Adhesion (both test media)	Poor	Poor	Poor	Excellent
Characteristics of Film (both test media)	Spongy	Spongy	Spongy	Hard

*Coating absorbed water, but substrate not rusted.

1. General Mills Inc.
2. Whittaker, Clark, and Daniels, Inc.
3. E. I. duPont deNemours and Company, Inc.
4. Monsanto Chemical Company

Table 5

Low Cost-High Extender Modification

	Type "A" Formulation %wt.	High Extender Type "A" Formulation %wt.	Type "B" Formulation %wt.	High Extender Type "B" Formulation %wt.
EPON Resin Component				
EPON 815	48.8	34.8		
EPON 828			46.3	40.4
Mod-Epox	9.9	7.0	4.6	3.7
Asbestos Filler (Mineral Filler 1719[1])	18.2	28.8		5.1
Barytes 89[1]		28.9		
Silica 219[1]				47.5
Aluminum Powder 210[2]	18.2			
Talc 1767[1]			46.4	
Medium Chrome Yellow 469D[3]				3.3
Iron Blue 50-4100[4]		0.5		
Phthalocyanine Blue 284D[3]	4.9		2.7	
	100.0	100.0	100.0	100.0
Polyamide Resin Component				
Versamid 115[5]	35.7			
Versamid 125[5]	35.7	24.6	79.2	42.3
Genamid 250[5]		8.2		
Asbestos Filler (Mineral Filler 1719)		32.1		12.7
Barytes 89		32.1	9.9	
Silica 219				44.8
Aluminum Powder 201	23.8			
Talc 1767			9.9	
Medium Chrome Yellow	4.8	3.0		
Phthalocyanine Blue			1.0	
Lampblack B.T.A.[6]				0.2
	100.0	100.0	100.0	100.0
Parts by Weight of Polyamide Resin Component per 100 Parts EPON Resin Component	188.8	119.0	67.8	111.0
Percent excess Polyamide Resin over Stoichiometric Amount	136%	25%	16%	16.0%
Pigment Loading	33.0%	62.7%	37.6%	56.7%
Evaluation of:				
1. Application Variables				
Mixing Ease	Fair-Poor	Fair	Good	Fair
Degree of Sagging	Very slight	none	Mod-Severe	slight
Pot Life (hrs.)	1-1 1/2	1-1 1/2	1-1 1/2	1-1 1/2
2. Coating Performance after Three Months Three Months' Exposure				
Protection of Substrate in Salt Spray Environment	Excellent	Excellent	Excellent	Excellent
Protection of Substrate Immersed in 3% brine	Excellent	Excellent	Excellent	Excellent
Adhesion (both test media)	Fair	Excellent	Excellent	Excellent
Characteristics of film (both test media)	Spongy	Hard	Hard	Hard, resi chipping
Raw Material Cost Per Pound	$0.62	$0.30 (50% reduction in raw material cost)	$0.49	$0.34 (30% reduction in raw materia cost)

1. Whittaker, Clark, and Daniels, Inc.
2. Metals Disintegrating Company, Inc.
3. E. I. duPont deNemours and Company, Inc.
4. American Cyanamid Company
5. Generals Mills, Inc.
6. Monsanto Chemical Company

ABS-050332

Table 6

Evaluation of Type "A" and "B" Formulations Prepared Commercially

Submitted by	Pittsburgh Plate Glass Company	Napko Corporation	Pittsburgh Plate Glass Company	Napko Corporation	Cook Paint and Varnish Company
Formulation Type	"A"	"A"	"B"	"B"	"B"
Evaluation of:					
1. Application Variables					
Mixing Ease	Fair - Poor	Fair - Poor	Good	Good	Good
Degree of Sagging	Slt-Mod.	None	Mod.	Severe	Severe
Pot Life (hours)	1 - 1 1/2	1 - 1 1/2	1 - 1 1/2	1 - 1 1/2	1 - 1 1/2
2. Coating Performance After Three Months' Exposure					
Protection of Substrate in Salt Spray Environment	Excellent	Excellent	Excellent	Excellent	Excellent
Protection of Substrate immersed in 3% brine	Excellent	Excellent	Excellent	Excellent	Excellent
Adhesion (both test media)	Fair	Fair	Excellent	Good (due to sagging)	Fair (due to sagging)
Characteristics of Film (both test media)	Spongy	Spongy	Hard	Hard	Hard