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ZINC - RICH COATINGS: A MARKET SURVEY

Ruth Lizak

Prepared by
STANFORD RESEARCH INSTITUTE
Menlo Park, Calif. 94025

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16. Abstract

Zinc-rich coatings with both organic and inorganic binders have been considered for coastal bridges which require more corrosion protection than inland bridges because of exposure to salt spray and fog. Inorganics give longer protection and may be applied without a finish coat; however, those currently available are harder to apply than organics.

NASA's potassium silicate/zinc - dust coating (Tech Brief 70-10600) apppears to provide longer protection, resist thermal shock and overcome the application problem. Panels coated with the NASA formulation withstood 5308 hours in the California Department of Transportation Salt Spray Chamber with no rusting or blistering.

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EXECUTIVE SUMMARY

Coastal bridges require more corrosion protection than inland bridges because of their exposure to salt spray/fog. Painting the bridges at frequent intervals has been the usual (very costly) remedy.

Zinc-rich coatings with both organic and inorganic binders have been considered. Inorganics give longer protection and may be applied without a finish coat; however, those currently available are harder to apply than organics.

NASA's potassium silicate/zinc-dust coating (Tech Brief 70-10600) appears to provide longer protection, resist thermal shock, and overcome the application problem. The water-base binder sprays easily, adheres readily, and can be heavily loaded with zinc particles to provide uniform coverage. Panels coated with the NASA formulation withstood 5308 hours in the California Department of Transportation salt spray chamber with no rusting or blistering. The formulation selected for the test was:

	Percent by Weight
Potassium silicate solution	17.6
Methyltrimethoxysilane	0.4
Zinc dust, 325 mesh	82.0

The Golden Gate Bridge Authority will field test the NASA formulation in early 1975 by applying it to a girder of the famous bridge. Of particular interest to maintenance personnel will be its ease of application.

Material costs are estimated at $9.24 per gallon. Other production costs including labor and overhead are estimated at $2.60 per gallon,

for a total of $11.84 per gallon. With a 45% gross profit, not uncommon in the paint industry, the price could be $22.50 per gallon. Current prices for commercially available zinc-rich coatings range from $14.40 to $43.84. Initial costs for establishing a small operation that could deliver 5000 gallons of coating could be as low as $62,000.

A market size in excess of $2 billion is available currently for highway bridges, utility pipelines, nuclear reactors, and railcar hoppers alone. Other markets include off-shore drilling facilities, railroad bridges, and the shipping industry.

The NASA coating faces competition from established brands. Entering the market would be facilitated if the manufacturer already had some channels of distribution.

U.S. Patent No. 3,620,784 has been granted to NASA for its potassium silicate/zinc-dust coating. Patent rights may be licensed through the Patent Counsel of Goddard Space Flight Center, Code 204, Greenbelt, Maryland 20771. Exclusive rights may be considered.

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I BACKGROUND

Because of their exposure to salt spray, coastal bridges require more corrosion protection than is needed inland. Currently available coatings provide protection for about twenty years on inland bridges, but less than ten years of protection on bridges near the coast. In a study conducted by California highway engineers, a 25-year life inland was found to equal only 4-6 years on the coast.[1]

Bridge painting is an expensive procedure, mainly because of high labor costs. Painting of the Golden Gate Bridge, for example, requires 42 painters working for 5 years at $10.77 per hour. If coating life were doubled, savings in the neighborhood of $1 million per year could be realized for labor alone.

Zinc-rich coatings are known to provide excellent protection, and coatings with both organic and inorganic binders have been tested for bridge application. The inorganics have two advantages: they do not require a finish coat, and they give longer protection. However, currently available inorganic paints are harder to apply than organic coatings.

This problem appears to have been overcome by the potassium silicate zinc-dust coating developed at NASA's Goddard Space Flight Center for protection of the gantries at Kennedy Space Center. Potassium silicate is formulated into a thin, water-base binder that sprays easily, adheres readily, and can be heavily loaded with zinc particles to provide uniform zinc-dust coverage and hence greater protection against corrosion. Because it was developed for use at Kennedy Space Center, the coating was designed to resist (1) corrosion from salt spray/fog, (2) heat and fire from the rocket exhaust, and (3) the thermal shock created by rapid temperature changes.

To allow the transfer of the NASA coating from its aerospace origin to bridge protection applications, the coating must become available commercially. This survey of the market was undertaken to provide members of the paint and coating industry with the information they need in considering production and sale of this zinc-rich coating. This report describes the characteristics and test performance of the product and outlines the size of the market, capital investment, production costs, and the potential for sales and profit.

II NASA'S ZINC-RICH COATING

Technical Characteristics

NASA's potassium silicate/zinc-dust coating (TSP-70-10060) resists cracking, corrosion, and fire. It is self-curing* and easy to apply. Its greatest assest, however, is its adherence capability, even under extreme conditions such as salt fog and thermal shock.

Zinc has a higher electromotive potential than iron or steel and, in the presence of an electrolyte such as saltwater, will be sacrificed to protect the steel. When zinc ions go into solution, they liberate electrons, which cause a current flow into the steel to prevent ferrous ions from going into solution and beginning the electrochemical corrosion process. To function anodically, the zinc particles must be in intimate contact with one another so that the coating film is electrically conductive. Contact is achieved by very high zinc loading with a relatively small amount of binder.

Potassium silicate is known to be an effective binder for zinc dust, provided the mole ratios of silica to potassium oxide are maintained at a high level. The mole ratios of currently available zinc-rich coatings generally peak at about 3.1:1; however, because of its unique binder formulation, the NASA coating boasts a range of 4.8:1 to 5.3:1.

The NASA coating contains 19 to 23 parts (percent solids in solution) by weight of potassium silicate, plus zinc dust (at 6 to 27 times the percent by weight silicate solids). To this basic mixture, methyltrimethoxysilane is added in amounts up to 3% by weight to act as a buffer

*Many coatings are postcured, which requires spraying with water after application.

and to provide better adherence to steel. The silane also facilitates mixing with the zinc. The original formulations[2] are given in Table 1. The coating has a water base and is nontoxic and nonflammable.

Test Performance

Ten panels coated with formulations of NASA's zinc-dust composition were placed in the salt spray chamber at the California Department of Transportation's Materials and Testing Laboratory on March 11, 1974. The formulation selected for this test was:

	Percent by Weight
Potassium silicate solution 20K 5.3	17.6
Methyltrimethoxysilane	0.4
Zinc dust, 325 mesh	82.0

Seven of the panels were given the following antifouling topcoats (developed for use on Navy vessels):

Urethane-polyester (vinyl phenolic tiecoat)
Epoxy (vinyl phenolic tiecoat)
Vinyl acetate
Vinyl acetate (vinyl phenolic tiecoat)
Chlorinated rubber (vinyl phenolic tiecoat)
Vinyl chloride (vinyl phenolic tiecoat)
Vinyl chloride GW (vinyl phenolic tiecoat)

All three panels coated with the zinc-dust formulations alone gave excellent performances, with no rusting or blistering after 5300 hours in the salt spray chamber (Figure 1). The vinyl acetate with vinyl phenolic tiecoat also withstood a 5300-hour test with no sign of corrosion (Figure 2). California engineers consider a coating superior if it endures a 3000-hour test (3% brine), whereas the paint industry places its test requirement as high as 4000 hours.

Table 1

PREFERRED FORMULATIONS* OF NASA'S ZINC-DUST COATING

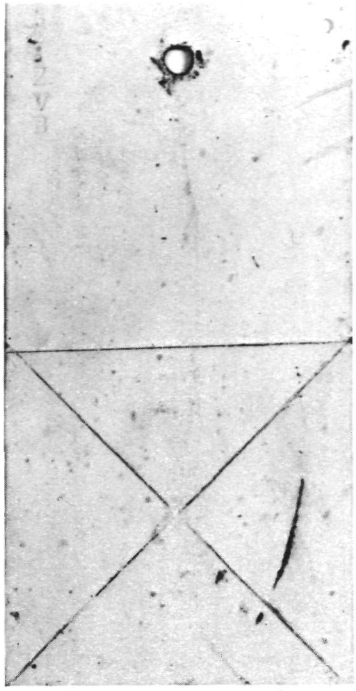
Component	Parts by Weight	Percent by Weight
Example I		
Potassium silicate solution 20K5.3 †	64.5	21.0
Methyltrimethoxysilane	2.0	0.6
Zinc dust	240.0	78.4
	306.5	100.0
(After 4 hours air drying, the coating was assayed at 94.4% Zn + silicone)		
Example II		
Potassium silicate solution 22K4.8	64.5	26
Zinc dust	180.0	74
	244.5	100
Example III		
Potassium silicate solution 20K4.8	64.5	21.2
Zinc dust	240.0	78.8
	304.5	100.0

Component	Parts by Weight	Percent by Weight
Example IV		
Potassium silicate solution - 22K4.8	64.5	21.2
Methyltrimethoxysilane	2.0	0.6
Zinc dust	240.0	78.2
	306.5	100.0
Example V		
Potassium silicate solution - 20K5.3	64.5	21.2
Zinc dust	240.0	78.8
	304.5	100.0
Example VI		
Potassium silicate solution - 19K5.3	64.5	17.6
Zinc dust	300.0	82.0
Methyltrimethoxysilane	2.0	0.4
	366.5	100.0

* Each of the above formulations was sprayed on steel surface, air dried at ambient temperature for 4 hours, and visually and microscopically examined. In each case a *firm adherent film* was produced. The compositions containing the methyltrimethoxysilane appeared slightly more adherent when subjected to scraping tests and evidenced a more glossy finish.

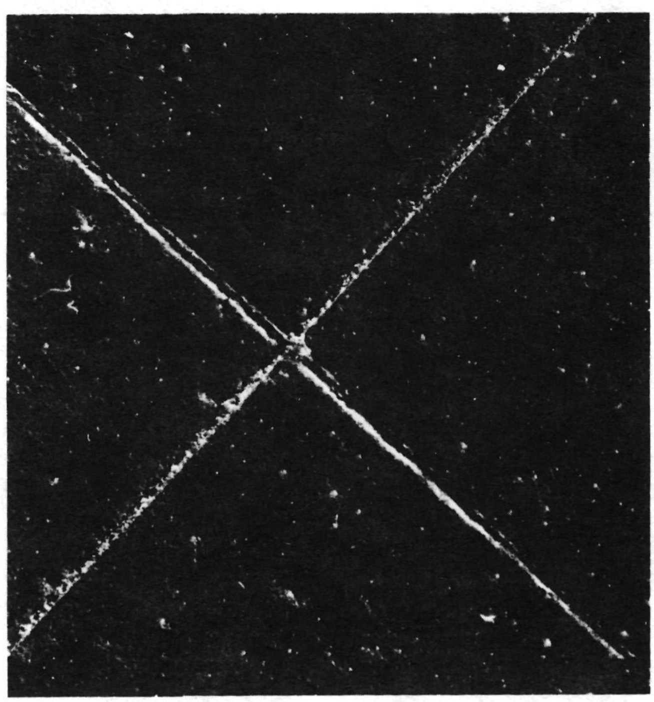
Source: NASA Technical Support Package for Tech Brief 70-10600, "Potassium Silicate Zinc Dust Coating."

† The first number refers to the percent by weight of potassium silicate in aqueous solution; the second refers to the mole ratio of silica to potassium oxide.



(a) WITH VINYL ACETATE FINISH COAT

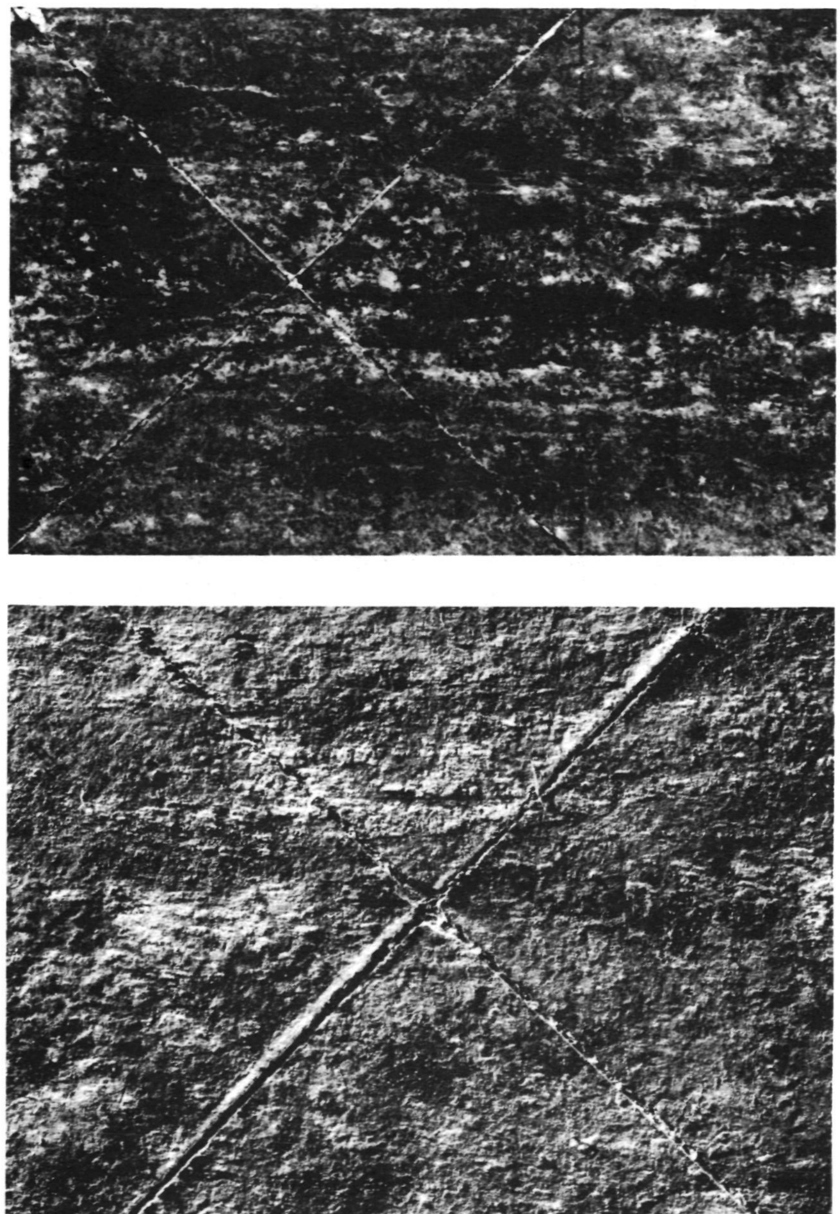
(b) FINISH COAT AND ZINC PRIMER REMOVED



(c) SAME AS (b), MAGNIFICATION 3X

SA-3670-2

FIGURE 1 NASA's POTASSIUM SILICATE ZINC DUST COATING AFTER 5300-HOUR SALT SPRAY TEST—NO SIGN OF CORROSION



MAGNIFICATION 3X

SA-3670-8

FIGURE 2 NASA's POTASSIUM SILICATE ZINC DUST COATING AFTER 5300 HR SALT SPRAY TEST

Tests of Commercial Coatings

Fifty-nine zinc-rich coatings, all available commercially, were exposure tested at Kennedy Space Center (KSC).[3] Seventeen were able to endure the 18-month test by completely resisting corrosion and adhering uniformly; however, only nine performed well in the abrasion test* (see Table 2). Figure 3 shows some of the coatings that were reported to perform poorly. All coatings were applied at 4 to 6 mils dry film thickness in accordance with KSC-SPEC-F-0020 with no top coat. Conclusions drawn from these tests were:

- Inorganic zinc-rich coatings are far superior to organic ones in the aggressive KSC seacoast atmosphere.
- Topcoats are not necessary, or even desirable, in conjunction with inorganic zinc-rich coatings in the KSC environment.
- The best performers were the hardest to apply.
- Nine commercial products (all inorganic) resisted corrosion and abrasion.

After 36 months, all the inorganics listed below continued to perform well.

Solvent-Base	Water-Base
Carbo Zinc 11, Carboline Corporation	Inorganic Zinc #1, Koppers Co.
Catha Cote 300, Devoe & Raynolds Company	Zinc 1, Mobil Chemical Co.
Ganacin Inorganic 347-931, E.I. du Pont de Nemours & Company, Inc.	Napko 4Z, NAPCO Corporation
Durazinc 525, Southern Imperial	Zinc-clad 8, Sherwin Williams Co.
Plasite 1000, Wisconsin Protective Coating Corporation	

Florida provides a grueling test environment. Studies conducted by the Rocky Mountain Society for Paint Technology and by the State of Delaware compared their exposure areas with the Florida environment.[4,5] In both cases, specimens at the Florida test site eroded sooner, indicating

*Federal Test Method Standard 141a, Method 6192, using a Tabor Abrader equipped with CS-17 wheels and a 1000-gram load.

Table 2

SURVEY OF ZINC-RICH PAINTS

(August 1974)

Company	Identification	No Rusting/Blistering: KSC 18-mo Field Test	No Rusting/Blistering: Alaska 2-yr Field Test	Coats: Primer	Coats: Topcoat	Cost/Gallon
Ameron Inc. Brea, Ca.	Dimetcote-6 (D-6) (alkyl silicate)	x		1 (4-6 mils)		$21.75 (5-gal lots)
* Carboline Co. St. Louis, Mo.	Carbo Zinc 11 (silicate)	x		1 (4-6 mils)	1	
Cook Paint & Varnish Co. N. Kansas City, Mo.	Epicon R-Zinc 920-A-170	x		1 (3 mils)	1	$27.00
* Devoe & Raynolds Co. Newark, N.J.	Catha Cote 300 (post-cured silicate)	x		1 (4-6 mils)	1	discontinued
Debevoise Brooklyn, N.Y.	Debanode 587 Organic		x	1 (2 mils)	2	$33.50
* E.I. du Pont de Nemours & Co., Inc. Wilmington, Del.	Ganacin Inorganic 347-931	x		1 (2 mils)	1 (2 mils)	$18.75 (5-gal lots)
Exxon Chemical Co. (formerly Enjay) Houston, Texas	Rustban 191 (silicate)	x	x	1 (6-9 mils) 2 (2 mils)		$25.90 (5-gal lots)
Glidden Durkee Cleveland, Ohio	Zinc dust primer (inorganic)		x	2 (4-5 mils) 1 (2 mils)		$12.00 (5-gal lots unmixed binder)
* Koppers Co., Inc. Pittsburgh, Pa.	Inorganic Zinc #1 (post-cured lead silicate)	x		1 (2 mils)	1	$21.60 (5-gal lots)
* Mobil Chemical Co. Azusa, Ca.	Zinc 1 (metallic silicate)	x		1 (4-6 mils)	1	$43.84 (5-gal lots)
Mobil Chemical Co. Azusa, Ca.	Zinc 4 (organic epoxy)	x		1 (4-6 mils)	1	$36.54 (5-gal lots)
* NAPKO Corporation Houston, Texas	Napko 4Z (self-curing inorganic silicate)	x		1 (3-6 mils)	0	$23.50 (5-gal lots)
NAPKO Corporation	Napko 2Z (polyhydroxy ether resin)	x		1 (3-6 mils)	0	$18.70 (5-gal lots)
Rustoleum Corp. Evanston, Ill.	Metallic Galvanoleum 3216		x	2 (1.5 mils)	0	$14.40 (5-gal lots)
Seaguard Portsmouth, Va.	Seaguard 6 (single component)	x		1 (4-6 mils)	1	†
* Sherwin Williams Cleveland, Ohio	Zinc-clad 8 (inorganic silicate)	x		1 (4-6 mils)		$23.80
* Southern Imperial New Orleans, La.	Durazinc 525 (inorganic silicate)	x		1 (4-6 mils)	1	$26.90 (5-gal lots)
* Wisconsin Protective Coating Corp.	Plasite 1000 (inorganic silicate)	x		1 (4-6 mils)		$32.00
Wisconsin Protective Coating Corp.	Plasite 1636 (organic epoxy)	x		1 (4-6 mils)		$32.50
Zinc Lock Co. Emeryville, Ca.	Zinc Lock 351 (silicone)	x		1 (4-6 mils)		Out of business

* Passed KSC abrasion test: Federal Test Method Standard 141a, Method 6192, using a Tabor Abrader equipped with CS-17 wheels and a 100-gram load.

† No response to inquiry

Source: SRI

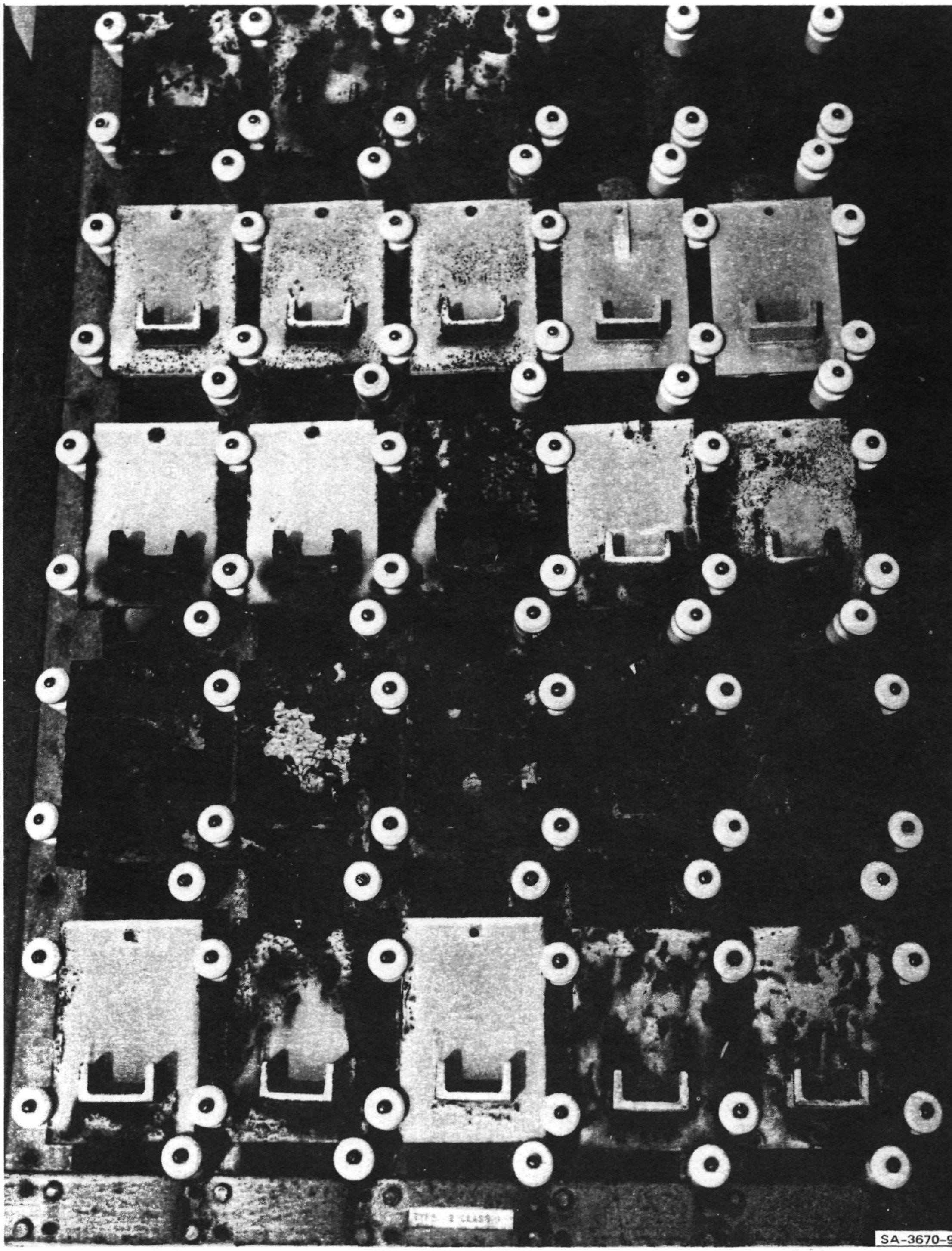


FIGURE 3 MISCELLANEOUS COATING FAILURES AT KSC TEST SITE

that the combination of moisture, humidity, and salt fog is a more damaging environment than moisture or salt fog alone or high altitude.[4]

Field tests were also conducted at Fairbanks, Alaska, by the Alaska Highway Department. Four coatings that performed well during this 2-1/2 year test (early 1971 to mid-1973) are included in Table 2.

Competitive Formulations

Many of the inorganic materials used in the past are reported to have solved most of the problems of metal coatings, such as poor adherence, poor finish characteristics, and uneven coverage. Generally the solution is stated to lie in use of an alkali metal silicate solution as the vehicle. Specific formulations have been proposed, using sodium silicate in a mole ratio of sodium oxide (Na_2O) or potassium oxide (K_2O) to silica (SiO_2) greater than the normal 1:2, preferably between 1:2.3 and 1:3.0. Even with these modifications in component ratios, however, the techniques require that additive components be incorporated into the composition to provide or enhance the requisite properties. These additives include lead chromate to render the coating insoluble or a fatty acid for spreadability and adhesion. Further suggestions include overcoating with acid formulations to ensure neutralization, particularly when corrosive environments are encountered.

In practice, however, these proposals have not proved totally satisfactory. The principal problem has been that each time a new material is added to solve one problem, other problems are accentuated. Several examples are given below.

"Galvanite" baked coatings of sodium silicate pigments with zinc dust have shown no evidence of deterioration nine years after application to 240 miles of overland pipe in Australia.[6]

Disadvantage: Need for baking.

Organic zinc-rich coatings are actually primers, not coatings. For all practical purposes, organics are not considered one-coat systems. With a finish coat, the organic still provides less protection than an inorganic without a topcoat.

Disadvantages: Require finish coat
Shorter life.

Alkyl silicate primers, when hydrolyzed to a level of about 80%, require no further processing. They use high-purity zinc dust having a controlled particle size distribution (6 micron average). Several additives, such as alkyl borates, are needed to produce a continuous film. Since the borates are water soluble, their silicate complexes are also sensitive to moisture. An example of an alkyl silicate formulation is provided in Table 3.

Advantages: May be stored at temperatures below 32 $^{\circ}$F
May be applied in wet weather

Disadvantages: Atmosphere moisture causes binder to gel
Limited pot life after mixing
Coating tends to run.

Vinyl primers are particularly applicable to water service. The zinc is combined with a vinyl solution. Just before mixing, a silane adhesion promoter is added. An example of a vinyl primer is given in Table 4.

Disadvantage: Organic primer--shorter life; requires finish coat

Phenoxy primers are the only single-package coatings; that is, the zinc dust is premixed with the binder. Solvents, such as methyl ethyl ketone, dissolve the phenoxy resin; suspending agents, such as xylene, prevent hard settling of the zinc dust. Molecular sieves are used to absorb moisture in the finished formulation and thus minimize gassing.

Table 3

ALKYL SILICATE ZINC-RICH PRIMER FORMULATION

(MP-3513)

	Formulation (lb/100 gal)
Component I (vehicle)	
Cellosolve silicate X-8018	698
Trimethylborate[(1)]	12.5
Fumed silica[(2)]	12.5
Component II	
Zinc dust[(3)]	1132
	Properties
Vehicle properties	
Flash point (tag closed cup), °F	110
Hydrolysis level, (approximate), %	80
Type of solvent	Cellosolve
Paint mixed with zinc dust	
PVC, %	61.14
Weight per gallon, lb	18.56
Nonvolatile, % by wt	72.14
Zinc dust in total dry film, %	82.25
Film properties (3.0 mils dry)	
Set to touch, minutes	40
Dry to handle, hours	6
Dry to topcoat, hours	48
1000-hours salt fog	Excellent
1000-hours Cleveland humidity	Excellent
1000-hours fresh water immersion	Excellent

(1) 70% azeotrope of TMB, Ventrol Corporation

(2) "Cab-O-Sil 11" H5, Cabot Corporation

(3) "Federated" No. 111, ASARCO, "Standard" No. 144, New Jersey Zinc Co. or equivalent

Source: Union Carbide Corporation

Table 4

ORGANIC ZINC-RICH PRIMER FORMULATIONS

Components of Phenoxy Zinc-Rich HP-3662[1]	Formulation (lb/100 gal)	Components of Vinyl Zinc-Rich VZ-108c[2]	Formulation (lb/100 gal)
Bakelite phenoxy resin PKHH	123.0	Component A	
MPA-60/xylene[3]	6.5	Bakelite vinyl resin VYHH	109.2
Cellosolve acetate	432.5	Methyl n-butyl ketone	397.1
Toluene	86.7	Methyl ethyl ketone	137.0
Linde molecular sieve 4A	10.7	"Bentone" 14[4]	4.6
Zinc dust 22[5]	1197.8	"Bentone" 27[4]	2.7
		Methanol	3.3
		Red iron oxide R-6098[6]	7.9
		Component B	
		Union Carbide A-1120 silane	4.1
		Component C	
		Zinc dust 222[5]	550.0

	HP-3662 Properties	VZ-108c Properties
Vehicle properties		
Flash point (tag closed cup), °F	80	Below 60
Type of solvent	Cellosolve acetate	Ketones
Paint mixed with zinc dust		
PVC, %	62.55	49.7
Weight per gallon, lb	18.57	12.17
Nonvolatile, % by wt	71.77	55.8
Zinc dust in total dry film, %	89.85	81.06
Film properties		
Set to touch, minutes	15	10
Dry to handle, minutes	60	15
Dry to topcoat, hours	4	1
Primer plus vinyl topcoat system		
1000-hours salt spray	Excellent	Excellent
1000-hours Cleveland humidity	Excellent	Excellent
1000-hours fresh water immersion	Good (few blisters)	Excellent

(1) Suggested for California Spec. 721-80-62
(2) Corps of Engineers, U.S. Army, CE-1409
(3) Baker Castor Oil Company
(4) NL Industries
(5) New Jersey Zinc Company
(6) Pfizer Chemical Company

Source: Union Carbide Corporation

An example of a phenoxy zinc-rich formulation is also given in Table 4.

Advantages: Single-package application

Disadvantages: Organic primer--shorter life; finish coat required.

Aluminum-zinc-rich coatings being developed at Alcoa substitute 10% aluminum for zinc. Aluminum is currently less expensive than zinc and may have other advantages.

Possible advantages: Retards gelling of binder
Potential one-package system.

Coating Application

The application process is generally considered the primary barrier to complete acceptance of inorganic zinc-rich coatings. During a presentation at the National Zinc Conference in Chicago, December 1974, Mr. J. L. Manta, President of J.L. Manta, Inc., a Chicago paint contractor, expressed his opinion that the steel surface must be sandblasted white-clean* (no stains, no pits, no grease or dirt) for the inorganic primer to adhere. Manufacturers of inorganics contend that only a near-white surface is required.† That is, the surface must be free of grease, dirt, and paint but may contain stains and mill scale binder. The heavier the steel, the harder it is to clean.

When the sandblasting (or steel grit blasting) is done in the open, as is necessary for bridge members, a dry abrasive of uniform grain size is discharged through a nozzle outlet of specific size at a predetermined pressure. With a 3/8-inch-diameter nozzle and a 90-pound air pressure, 3 to 6 ft/min. can be cleaned with 72 pounds of abrasive.

* NACE (National Association of Corrosion Engineers) Standard No. 1

† Steel Structures Painting Council Surface Preparation Specification No. 10.

Like other inorganics, the NASA coating is a two-component system. The zinc dust must be combined with the binder at the site. The mixing step is eliminated by using air spray equipment that contains an agitator. The spray gun should be held close to the structure so that coating is sprayed wet and zinc dust is not lost.

The NASA coating is applied at a dry film thickness of 2-3 mils. One gallon is reported to cover 375 square feet, whereas the usual coverage for inorganics is about 200 square feet per gallon. The potassium silicate binder appears to be easier to apply than the more common ethyl silicate. If necessary, a second coat or a topcoat may be applied after 24 hours. Complete self-cure requires five days.

III SUPPLIERS

Suppliers of Raw Materials

The NASA coating contains three ingredients: zinc dust, potassium silicate, and methyltrimethoxysilane (plus water for dilution). The supply of zinc dust is limited and may create some inconvenience. Suppliers with assets over $100,000 are listed below.

Pacific Smelting, Torrance, California
Kraft Chemical Company, Chicago
Sipi Metals Corporation, Chicago
Ball Corporation, Muncie, Indiana
Anchor Alloys, Inc., Brooklyn, New York
Belmont Smelting & Refining Works, Brooklyn, New York
Ney Metals, Inc., Brooklyn, New York
Republic Metals Company, Brooklyn, New York
American Smelting and Refining Company, New York
International Minerals & Metals Corporation, New York
New Jersey Zinc Company, New York
Phillipp Brothers Chemicals, Inc., New York
J. A. Samuel & Company, New York
I. Shumann & Company, Cleveland, Ohio
Amchem Products, Inc., Ambler, Pennsylvania

The zinc industry produced a record high of 1,488,937 tons of zinc during 1973, due to an all-time high in the production of automobiles and trucks as well as a continued boom in highway construction. Of this total, U.S. smelters could produce only 687,861 tons, leaving the balance to be provided by the government stockpile and foreign imports. Zinc dust production and shipments for 1972 and 1973 are shown (in tons) on the following page.

	1972	Preliminary 1973
Stock at beginning	936	4,686
Production during year	53,199	44,049
Shipments	49,449	47,740
Producers' stocks at end	4,686	995

The potassium silicate solution used in the NASA coating is supplied by Sylvania's Chemical Division and is designated PS-7. PS-7 required only 15 minutes to dissolve the silane.

Dow Corning makes the methyltrimethoxysilane under the designation Z6070. The material is flammable, with a low flash point, and must be stored in a cool place.

The paint industry expects, and gets, a great deal of technical service from its suppliers. Suppliers of raw materials provide technical information on use of their products, suggested paint formulations incorporating the products, application data, test results, and outdoor exposure data. Suppliers also provide technical assistance when difficulties are experienced in formulations containing their products, even though the problem may lie with another supplier's component.

A high degree of lot-to-lot uniformity in raw materials is required in the paint industry. Such uniformity is essential both in trade sales paints, where the same product may be made in a number of different plants, and in industrial finishes, where paint batches supplied at different times must match each other closely. Some suppliers have built large volumes of sales, less because of any inherent superiority in their products than because of their good quality control.

Prime Contenders

Not all major paint companies manufacture zinc-rich coatings. Table 5 lists the twenty-five largest paint manufacturers in the United States with their estimated coating sales. Table 6 lists all major manufacturers of zinc-rich coatings known to the author, six of which may be found among the paint manufacturers of Table 5.

Imports/Exports

The manufacture and sale of paint are primarily domestic businesses. Exports of paints and related products in 1964 were about $33 million, roughly 1.5% of domestic sales. Imports were below $4 million. There has been little change in either imports or exports during the last ten years.

Although exports are low, most of the major U.S. paint companies have manufacturing operations or licensing arrangements abroad, and particulary in Canada

Table 5

THE 25 LARGEST U.S. PAINT MANUFACTURERS

(Companies are listed in order of their roughly estimated sales of coatings only at the manufacturer's level. Sales of companies with their own retail outlets have been adjusted to eliminate consumer markup).

Rank	Company	Estimated Coating Sales ($ millions)
* 1	The Sherwin-Williams Company	$170
* 2	E. I. du Pont de Nemours & Co., Inc., Fabrics and Finishes Department	150
3	Pittsburgh Plate Glass Company, Coatings and Resins Division	130
* 4	Glidden Company, Coatings and Resins Group	90
* 5	Mobil Finishes Company and Socony Paint Products Company	65
* 6	Devoe & Raynolds Company (subsidiary of Celanese Corp)	65
7	DeSoto Chemical Coatings, Inc. (controlled by Sears Roebuck)	60
* 8	Cook Paint & Varnish Company	50
9	National Lead Company	40
10	Benjamin Moore & Company	35
11	Interchemical Corporation, Finishes Division	30
12	Rinshed-Mason Company	30
13	Hunt Foods & Industries, Inc., W. P. Fuller & Company Division	25
14	ConChemCo, Inc.	24
15	Armstrong Paint & Varnish Works, Inc.	23
16	Pratt & Lambert, Inc.	22
17	Reliance Universal, Inc.	20
18	Baltimore Paint & Chemical Company	19
19	Valspar Corporation	18
20	H. K. Porter Company, Hardware and Industrial Division	17
21	U.S. Gypsum Company	15
22	Mary Carter Paint Company	15
23	Montgomery Ward & Company	15
24	Minnesota Paints, Inc.	15
25	Ford Motor Company	15

*Performed well in KSC test.

Source: Estimated by C. H. Kline & Co.[8]

Table 6

MAJOR MANUFACTURERS OF ZINC-RICH COATINGS

Ameron Corporation

American Abrasive Metals Company

Carboline Company

Con-Lux Coating, Inc.

Cook Paint and Varnish Company

Devoe & Raynolds Company

E. I. du Pont de Nemours & Company, Inc.

Enjay Chemical Company

Essex Chemical Corporation

Glidden-Durkee Company

Grow Chemical Coatings

Koppers Company, Inc.

Mobil Chemical Corporation

NAPKO Corporation

Plas-Chem Corporation

Rust-Oleum Corporation

Seaguard Corporation

The Sherwin-Williams Company

Southern Imperial Coatings Corporation, Inc.

Wisconsin Protective Coating Corporation

Zinc Lock Company

Source: SRI

IV COSTS

Raw Materials

Processing of the NASA coating is a simple operation. The potassium silicate is purchased in solution, and only the silane needs to be added. The zinc dust is supplied separately and combined with the binder at the time of application. In fact, the zinc dust may be obtained locally to avoid shipping costs.

The price of zinc dust has vacillated greatly during the past year. It was 16¢ per pound in December 1973 and rose to 75¢ in mid-1974. By December 1974, the price had dropped to 52¢ per pound and was expected to level off at about 40¢ in 1975.

The December 1974 release on ceiling prices for zinc permitted domestic prices to rise to the world level, thus restoring a more regular flow of zinc, which is truly an international commodity. The increased prices of zinc also made construction of new or expanded zinc smelter capacity in the United States more certain, as producers can see a more reasonable return on investments of many millions of dollars. Four American producers have announced plans for expansions or new smelters, which will help the country to be less dependent on imports.

The potassium silicate solution, PS-7, can be purchased from Sylvania in returnable stainless steel drums (5-gallon capacity) or disposable plastic ones, at a cost of $2.94 per gallon and $3.43 per gallon, respectively, F.O.B. Towanda, Pennsylvania. For the returnable drums, a deposit of $65 each is charged. Thus, for 30 gallons (6 drums), the required deposit would be $390. Shipping costs are small but must be considered--approximately $25 for 50 gallons by truck from Towanda, Pennsylvania, to Menlo Park, California, for example.

The cost of Dow Corning's methyltrimethoxysilane is $2.47 per pound in 37.5-pound lots. For convenience, the lots may be broken down into 1 and 2-pound cans.

In Table 7 , raw material costs are estimated for one gallon of NASA's potassium silicate/zinc dust coating.

Equipment

Most paints, which have a heavy weight and consistency, require an assortment of rugged machinery. Equipment recommended for a typical small paint plant manufacturing many types of paints and coatings includes three mixers, three mills of different types, a high-speed agitator, twenty portable tanks, scales, and electric hoist, strainers, filling attachments, and conveyors.[9]

The manufacture of zinc coatings is a simpler operation that can be undertaken by a small business. Up to 2000 gallons/day of the NASA coating can be manufactured with only a scale for measuring ingredients, a reaction tank with an agitator, and a hoist. The scale must be accurate, rugged, and require little or no adjustment. Estimated costs for this equipment are given below.

Heavy-duty bench scale	$585
Reaction tank (43 gal) with 1/4 H.P. agitator	850
Electric hoist	480
Total	$1,915

If a beam scale requiring manual adjustment ($200-250) were used and a manual hoist ($400), the cost of basic equipment could be as low as $1500.

Table 7

RAW MATERIAL COST

FOR NASA'S POTASSIUM SILICATE/ZINC DUST COATING

Ingredient	Quantity		Price	Estimated Cost (per gallon coating)
	For 1 gal	For 100 gal		
Zinc dust	16.00 lb	1600 lb	$0.52/lb	$7.80
Potassium silicate solution	4.20 lb	420 lb	0.29/lb	1.17*
Methyltrimethoxysilane	0.11 lb	11 lb	2.47/lb	0.27
	20.31 lb			$9.24

* F.O.B. Towanda, Pennsylvania

Source: SRI

Packaging

Since most sales will be made to state and local government agencies or to industrial companies, the 5-gallon steel drum can be used to minimize costs. Typical costs for these containers with pry-off lids are $159 per 100 of GA24 and $184 per 100 of GA26, F.O.B. shipping point.

Plastic containers fall in about the same price range and are equally satisfactory. However, attention must be given to load capability. For most plastics, the maximum weight that can be contained is 60 pounds.

Labels may be obtained in rolls of 1000 at approximately $50 per roll in 5000-label lots. An additional $25 is charged for preparation of the rubber plate. At this price the labels will be in one color only, on a white background.

Shipping

Shipping costs for 100 gallons of coating (approximately 2000 pounds) as quoted by Navajo Freight Lines in San Jose, California, are as follows:

San Francisco to Denver (approx. 1000 miles)	$124.80
San Francisco to Houston (approx. 2000 miles)	138.20
San Francisco to Phoenix (approx. 800 miles)	105.00

From these figures, an average shipping cost of $1.25 per gallon has been estimated. Delivery costs for the finished product can be minimized by locating plants at key points throughout the area to be served.

From the supplier's standpoint, the paint industry is relatively free of government regulation, at least in comparison with such industries as drugs or food. Labeling of paints is regulated by the U.S. Food and Drug Administration and by some states as well. The Federal Housing Authority and many local governments set specifications for the painting of buildings.

The federal government is an important user of paints, generally bought under one or more of the over 200 federal specifications on paints, pigments, or related products. An index to these specifications with instructions for purchasing is issued annually, with a cummulative monthly supplement: "Index of Federal Specifications, Standards, and Handbooks," General Services Administration, Washington, D.C. 20402, U.S. Government Printing Office. Annual subscription (including monthly supplements)$1.50.

The National Paint, Varnish, and Lacquer Association also publishes a quarterly "Guide to U.S. Government Paint Specifications," available only to members.

Production Costs

To get started and make a first delivery of, say, 5000 gallons would require an investment of approximately $2000 for equipment, $46,200 for raw materials, $2100 for packaging and labeling materials, and $6250 for shipping and receiving, for a total of $56,550. Spread over a 50,000 gallon production period (50 days at 1000 gallons per day), the equipment cost per gallon of coating becomes $0.04, and a total cost per gallon becomes approximately $10.00 (see Table 8). Labor costs for mixing and handling are estimated at 30¢ per gallon with overhead costs about twice that amount.

To cover material, profit, labor and overhead costs, a competitive price of $20-25 per gallon could be charged. The latest quote for a commercially available inorganic zinc-rich coating (January 1975) to the Golden Gate Bridge Authority was $35 per gallon. Locating the plant in a low-cost neighborhood can reduce overhead costs. However, communities that have low tax and utility rates should not be chosen if rail and truck facilities are not convenient. Consideration should also be given to

Table 8

COST AND PROFIT

	Cost*	Cost per Gallon
Capital equipment	$ 2,000	$0.04
Raw materials	46,200	9.24
Shipping/packaging	8,350	1.66
Labor	1,500	0.30
Overhead	3,000	0.60
Totals	$61,050	11.84
Competitive price		22.50
Cost		- 11.84
Gross Profit		$10.66

* Based on initial production of 5000 gallons.

† Spread over 50,000-gallon period.

Source: SRI

climatic conditions (the binder must be kept from freezing during storage and shipping).

A plant with a capacity of 1000gallons per day should have warehousing capacity for about 5,000 gallons. The estimated storage space required for this amount of stock is approximately 1000 square feet.

V BUSINESS CONSIDERATIONS

Sales Potential

Applications for zinc-rich coatings have been identified with state highway departments, utility companies, and railroads, particularly for coastal operation, and with the maritime services and off-shore drilling facilities.

State highway departments want greater protection for coastal bridges, particularly the large bridges that are difficult and expensive to paint. For example, to coat the Golden Gate Bridge, which has 23,000 pounds of steel per linear foot, approximately 5,000 gallons of inorganic zinc are needed. With an estimated 500,000 highway bridges in the United States averaging 2,500 gallons per bridge every 15 years, the total market could be 83 million gallons per year. Currently, inorganic coatings are being marketed by about twenty major paint companies. At $24 per gallon, each company could gross $94 million per year on bridge coatings alone.*

U.S. utility companies plan to spend $6 billion on lines and equipment in the next few years, with paint (mostly zinc-rich) accounting for $3.5 million. According to the Transportation Association of America, 228,550 miles of oil pipeline criss-cross the country in 1972, compared with 204,064 miles in 1962. Zinc-rich coatings are also being considered for protection of nuclear reactors. Each unit will require approximately 10,000 gallons. Although there are only about 45 nuclear reactors in the United States at present, the number is steadily climbing (forecast for 1984: 140). In short, public utilities are expected to have a sizable impact on the zinc-rich coating industry during the next five to ten years.

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*Current prices run as high as $43 per gallon.

The railroads are looking at inorganics to coat their hopper cars. The cars currently have a 40-year life, but the hopper walls become badly corroded within 20 years from the abrasive action of the hopper contents. Car replacement costs $30,000; replacing the hoppers costs $15,000. There are approximately 400,000 hopper cars in the United States.

To increase hopper life, zinc coating on the walls is being considered. Because of the abrasion factor, the hoppers may have to be recoated every 5 years. At about $500 per coating including labor costs, a considerable saving could be achieved ($2,000 in 20 years compared with $15,000 for wall replacement).

Off-shore drilling facilities are being coated with inorganics. Eight years ago, Freeport Sulphur Company put two coats of a zinc silicate (or one coat of zinc silicate plus a coat of polyimide epoxy) on its platform structures.* A twenty-year life is forecast. The two-coat system replaces the original five coats of vinyl. Each facility contains close to a million square feet of surface to be coated, at approximately 100,000 square feet per year. The petroleum/gas industry listed 12,000 offshore wells as of January 1974.[10]

A new vitality in American shipping has resulted in the addition (construction or conversion) of approximately 25 ships (cargo and passenger) per year. The current fleet consists of more than 1400 vessels, both government and privately owned. In 1964, 10 million gallons of paint (primer and finish coat) were applied to ships. Since the size of reserve fleets decreased and then rebounded during the past ten years, this gallonage may be about the same today.

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*As reported at the National Zinc-Coating Conference in Chicago, December 4-5, 1974.

No long-term forecasts of production were found for inorganic zincs. However, Table 9 projects the market for the entire surface coating industry (paints, varnishes, etc.) of which inorganic zincs are only a small percentage (less than 10%). Current trends indicate that the forecast is very conservative. Table 10, which shows the current demand for inorganic zinc-rich coatings, does not include the maritime market.

Commercial Channels of Distribution

Zinc-rich coatings are used primarily by public utilities and the public sector and are purchased in large quantities directly from the manufacturer. Large paint manufacturers have representatives in major cities.

Since the NASA-developed coating faces competition from established brands, its longer life and competitive price are not enough to assure a market. To enter the field successfully, a company probably should already have some channels of distribution, e.g., previous connection with highway, maritime, or public utility procurement. Companies that are current suppliers of paints/coatings, batteries, nonferrous metals, and metallic pigments could probably enter the market readily. Distribution centers in several coastal areas are advisable.

Patent Position

NASA has been granted a patent for its potassium silicate/zinc dust coating (U.S. Patent No. 3,620,784). Rights to the patent may be licensed through the Patent Counsel at Goddard Space Flight Center, Code 204, Greenbelt, Maryland 20771. Exclusive rights may be considered.

NASA will assist in the transfer of this technology to interested companies. Discussions may be held with NASA personnel as well as with the SRI Technology Applications Team.

Table 9

FORECAST DEMAND FOR SURFACE COATINGS

(millions of gallons)

Year	Trade Sales	Industrial	Total
1960			
Actual	344	319	663
1980			
Low	327	167	494
Medium	373	296	670
High	471	503	974
2000			
Low	306	302	608
Medium	452	653	1105
High	945	1377	2322

Source: H.H. Landsberg, L.L. Fischman, and J.L. Fisher, "Resources in America's Future" (Johns Hopkins Press, Baltimore, 1963).

Table 10

CURRENT DEMAND FOR INORGANIC ZINC-RICH COATINGS

(millions of dollars)

	Annual Market 1974 (at $24 per gal)	5% of Total	1% of Total
Highways	$1,992.0	$99.60	$19.90
Utilities			
Reactors	3.6	0.18	0.04
Pipeline	1.2	0.06	0.01
Railroads	1.9	0.10	0.02
Total	$1,998.7	$99.94	$19.97
	($2 billion)	($100 million)	($20 million)

Source: SRI

VI CONCLUSIONS

Not only does a market exist for a superior inorganic zinc-rich coating, particularly for coastal applications, but it is growing steadily. Problems encountered in applying the inorganics have retarded this growth, however. The NASA coating appears to have overcome the disadvantages while enhancing the advantages.

Most of the current $2-billion-per-year market is served by 20 paint companies. Entering this market will require a demonstration of product superiority, however, and such a demonstration has been initiated at the Golden Gate Bridge. The excellent performance of the NASA coating gives indication of a very viable business opportunity.

Technical Advantages of the NASA coating are:

- Ease of application
- Superior adhesion to grease-free carbon steel even in a salt environment
- Resistance to thermal shock
- Water base
- Self-curing
- High spread rate.

Production advantages include:

- Low production cost (approximately $10 per gallon, including labor, overhead, packaging, and shipping).
- Low capital investment (approximately $2000 plus building rental for a 5000-gallon-per-day operation).
- Immediate sales potential
- Large market size (approximately $2 billion per year and growing).

- Small-lot purchase of raw materials with little loss in buying power (approximately $3500 for 500 gallons).
- Ease of operation, requiring only the weighing and mixing of two binder components.

Patent position is good:

- Patent owned by NASA
- Rights may be licensed; exclusive rights will be considered.

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"The aeronautical and space activities of the United States shall be conducted so as to contribute . . . to the expansion of human knowledge of phenomena in the atmosphere and space. The Administration shall provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof."

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