

Recycling of Crushed Glass Into Coating Products



RECYCLING OF CRUSHED GLASS INTO COATING PRODUCTS

FINAL REPORT

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TABLE OF CONTENTS

| | Page |
|--|-----------|
| EXECUTIVE SUMMARY..... | 1 |
| 1.0 PROJECT OVERVIEW..... | 2 |
| 1.1 Scope of Project..... | 2 |
| 1.2 Project Objective..... | 2 |
| 1.3 Sources of Recycled Glass..... | 2 |
| 1.4 Elements of the Formula..... | 3 |
| 2.0 TEST PANEL PREPARATION AND RESULTS..... | 4 |
| 2.1 Test Panel Preparation Criteria..... | 4 |
| 2.2 Exposure Monitoring Record, Table 1..... | 5 |
| 2.3 Elongation, Reflectance and Gloss Test Results, Table II..... | 7 |
| 2.4 Formula Modification..... | 7 |
| 3.0 PRODUCTION BATCH FORMULA DEVELOPMENT..... | 7 |
| 3.1 Formula Development..... | 7 |
| 3.2 Batch Production and Testing..... | 8 |
| 3.3 Production Batch Application..... | 9 |
| 3.4 Production Batch Exposure Testing..... | 10 |
| 4.0 RESULTS OF RECYCLED GLASS TESTING..... | 10 |
| 4.1 Uses..... | 10 |
| 4.2 Results..... | 11 |
| ACKNOWLEDGMENTS..... | 12 |
| REFERENCES..... | 13 |

EXECUTIVE SUMMARY

The purpose of this project was to test the use of finely ground recycled post-consumer and post-industrial recycled glass in coating products. Ground glass may be a good substitute for crushed and ground naturally occurring crystalline silica products often used in these applications. Glass does not contain crystalline silica, and therefore does not have the occupational safety and health problems associated with those materials. The project started with a search of the literature on uses of silica in coatings. The researchers decided to concentrate on the development of a roof coating because the silica pigment extender often used in products of this type affect the elasticity and water resistance, which are both measurable performance criteria.

Two laboratory batches of roof coating containing glass were developed and tested for quality control and performance. Two commercially available products were obtained and tested along with the laboratory batches as a control. The laboratory batches were produced using two different binder systems to see how various types of glass would affect the properties of the coating. Both post-consumer and post-industrial recycled glass of different particle sizes and colors were evaluated. After the laboratory and performance testing, a final production batch formula was developed.

Eco Chemical, Inc., produced a production batch of 100 gallons in July 1995. The coating was applied in August to a test roof, alongside one of the commercial coatings for comparison. The test batch, which contained one and one quarter pounds of glass per gallon, compared favorably with the commercially available samples. The test roof will be inspected and evaluated quarterly. Eco is planning to pursue the product development of this and other coatings containing recycled ground glass.

1.0 PROJECT OVERVIEW

1.1 SCOPE OF THE PROJECT

To develop information on the use of finely ground recycled glass in an elastomeric roof coating. The glass is a substitute for crushed and ground naturally occurring crystalline silica. It has been recognized that crystalline silica dust contributes to lung disorders and is a suspected carcinogen. In contrast, glass has an amorphous structure and research has supported the fact that, even when finely ground, it is not a carcinogen. Only elastomeric coatings were evaluated in this project, but the information developed in this study is pertinent to a wide range of industrial filler applications for finely ground glass.

1.2 PROJECT OBJECTIVE

The objective was the formulation of a recipe and manufacturing procedure for elastomeric roof coating compounds with the substitution of recycled glass for crushed silica, using sources, colors, cleanliness, mesh size, and particle distribution of recycled glass currently available.

1.3 SOURCES OF RECYCLED GLASS

The sources are post-consumer clear, brown, and green glass from curbside collections, and post-industrial glass scrap. The post-consumer glass is contaminated with paper fibers from labels and food particle residue that could promote bacterial growth in finished waterborne products. The industrial scrap evaluated was the undersized fine particles from a grinding process to recycle clear plate glass into reflective glass beads. This by-product consisted of clean, clear glass, of which 94 percent was finer than 150 mesh. The most common materials used in this application have a fineness of 150 to 325 mesh (25 to 10 microns).

1.4 ELEMENTS OF THE FORMULA

In order to test and evaluate the different sources of glass, the type and fineness of particles, and the effect of glass color, a basic laboratory recipe was developed and used. This formulation contained the following ingredients (and sources):

- Binder (Specialty Polymers or Reichhold Chemical)
- Cosolvent (Dow Chemical)
- Dispersing agents
- Thickener
- Pigments:
 - Titanium Dioxide
 - Fire Retardant
 - Recycled Glass, all types and colors
- Defoamer
- Preservative
- Anti-fungal agent

The evaluation of physical properties, such as viscosity and water resistance, of the laboratory sample preparations led to the following formulation decisions:

- Use clear glass with a particle size less than 150 mesh;
- Use 1.25 pounds of glass per gallon of coating;
- Use 1.0 pounds per gallon of a non-chalking grade of rutile titanium dioxide to develop opacity and higher reflectance (white brightness);
- Use 0.5% of pigment weight of anionic dispersing agents;
- Use one and a half times the recommended level of preservative to prevent growth in the liquid product; and
- Use standard level of fungal agent.

2.0 TEST PANEL PREPARATION AND TEST RESULTS

2.1 TEST PANEL PREPARATION CRITERIA

Test panels were prepared from plywood and placed in such a way that maximum stress from sunlight and water would be exerted on the test coatings during exposure to the weather.

Four exposure panels were prepared using ½-inch exterior grade CDX plywood. They consisted of one-foot square pieces with built-up edges on three sides. These were to be exposed in a flat position resulting in the accumulation of water over approximately one-half of the surface. They were exposed on the roof of the ECO Chemical, Inc., manufacturing facility in Seattle, Washington. The panels were coated with:

1. glass lab sample 11-5 - RCI Binder.
2. glass lab sample N-1 - Specialty Polymers Binder.
3. Competitive sample of Atco Elastomeric roof coating.
4. Competitive sample of Snow-Roof Elastomeric white roof coating.

The panels were prepared by brush, coating three coats of each roof-coating sample onto all sides of an exposure panel. After application of the coatings and allowing two weeks for curing under laboratory conditions, the panels were mounted on the roof on December 29, 1994. The comparison of the laboratory samples with recycled glass to the commercial products would indicate whether the glass caused any decrease in durability.

2.2 TEST PANEL EXPOSURE RESULTS

The appearance of the test panels was monitored for dirt collection, yellowing, cracking, blistering and peeling. Special attention was given to blistering, erosion, peeling or appearance changes in the ponding water areas. At the end of eight months, the samples with recycled glass content did not show any serious reduction of exposure performance. It was judged that the development of the production batch formula could safely proceed. A record of the exposure test panel monitoring follows in Table I.

TABLE I TEST PANEL PREPARATION RECORD

| Date | Sample | Description | Preparation |
|----------------|------------------------|-------------------------|--------------------|
| 1/25/95 | Snow-roof S-100 | Initial Exposure | 3 Coats |
| 1/25/95 | Atco | Initial Exposure | 3 Coats |
| 1/25/95 | 11-5 | Initial Exposure | 3 Coats |
| 1/25/95 | B-1 | Initial Exposure | 3 Coats |

EXPOSURE TEST PANEL MONITORING RECORD

| DATE | SAMPLE | CONDITION | LEVEL |
|----------------|-----------------|--|---|
| 2/22/95 | Snow-roof S-100 | Blistering Discoloration Softening | None Light Moderate |
| 2/22/95 | Atco | Blistering Discoloration Softening | None None Slight |
| 2/22/95 | 11-5 | Blistering Discoloration Softening | None Slight Slight |
| 2/22/95 | B-1 | Blistering Discoloration Softening | None None Very slight |
| 6/25/95 | Snow-roof S-100 | Blistering Discoloration Softening Fungus | None Slight Moderate Moderate growth |
| 6/25/95 | Atco | Blistering Discoloration Softening Fungus | None None Slight None |
| 6/25/95 | 11-5 | Blistering Discoloration Softening Fungus | None Light Slight None |
| 6/25/95 | B-1 | Blistering Discoloration Softening Fungus | None None Very slight None |

EXPOSURE TEST PANEL MONITORING RECORD (continued)

| | | | |
|----------|-----------------|--|--|
| 11/17/95 | Snow-Roof S-100 | Blistering Discoloration Softening Fungus | None Slight reddish Slight Moderate reddish colored growth |
| 11/17/95 | Atco | Blistering Discoloration Softening Fungus | None Slight reddish Slight None |
| 11/17/95 | 11-5 | Blistering Discoloration Softening Fungus | None Slight-dirt Slight None |
| 11/17/95 | B-1 | Blistering Discoloration Softening Fungus | None Slight amount of dirt Very slight none |

The results of the test panel monitoring indicated that the blistering and softening was due to poor water resistance, discoloration was due to dirt accumulation, and fungus growth were the result of property differences in the binders and not from the substitution of crushed glass for the silica.

2.3 ELONGATION, REFLECTANCE AND GLOSS TEST RESULTS

The laboratory sample and competitive products were tested for elongation by preparation of a ten-mil free film. One-inch strips were clamped and weighted to determine the length of elongation at the break point. Elongation is an important property for determining the flexibility and resistance to cracking of the coating. If the coating cracked and allowed the entry of water, severe failure would result.

The 60-degree and 85-degree specular gloss and the total reflectance of each sample were also measured. The gloss is important in determining smoothness and resistance to dirt accumulation, and the reflectance relates to the coatings' ability to reflect the radiant energy from the sun. The reflectance data indicates how reflectant to radiation energy the coating is or how white it is. The results are tabulated below in Table II.

TABLE II ELONGATION AND REFLECTANCE TESTING

S = Start (length in inches) B = Break (length in inches) D = Difference

| Test Number | Snow Roof | Atco | 11-5 | B-1 |
|----------------------------------|------------------|-------------|-------------|------------|
| 1 | S-1.75 | S-1.75 | S-2.0 | S-1.75 |
| | B-7.5 | B-3.50 | B-3.5 | B-6.10 |
| | D-5.75 | D-1.75 | D-1.50 | D-4.35 |
| 2 | S-1.625 | S-1.75 | S-1.75 | S-1.75 |
| | B-6.5 | B-3.375 | B-2.50 | B-5.10 |
| | D-4.875 | D-1.625 | D-1.00 | D-4.75 |
| 3 | | S-1.75 | S-1.875 | S-1.75 |
| | | B-3.25 | B-2.875 | B-6.5 |
| | | D-1.5 | D-1.0 | D-4.75 |
| 4 | | | S-1.75 | |
| | | | B-3.002 | |
| | | | D-1.25 | |
| Average S/D | 1.75/5.375 | 1.75/1.625 | 1.84/1.25 | 1.75/4.15 |
| % Elongation D/S | 307 | 93 | 68 | 237 |
| 60 degree gloss | 7.9 | 8.5 | 4.1 | 5.8 |
| 85 degree gloss | 5.9 | 9.5 | 1.8 | 4.7 |
| Percent Total Reflectance | 91.2 | 90.0 | 83.3 | 69.1 |

2.4 FORMULA MODIFICATION

After evaluation of the laboratory testing and the exterior exposure results, the decision was made to use a modified version of laboratory B-1 as the basis for the production batch.

3.0 PRODUCTION FORMULA DEVELOPMENT, BATCH PRODUCTION AND QUALITY CONTROL TESTING

3.1 JUSTIFICATION

In July 1995, it was decided to move forward with the production batch so the test roof could be completed during favorable weather.

3.1.1 Formula development

One hundred and fifty pounds each of green, brown and clear glass, ground to approximately 150 mesh, were obtained from a chain flail grinder in Bend, Oregon. One hundred and twenty-five pounds of glass were required for the production batch. Review of laboratory formula B-1 and the quality control test results for grind, weight per gallon, viscosity and white brightness indicated the following:

- The dispersing agent level was satisfactory (grind evaluation);
- The defoamer needed to be changed to one with more activity to reduce air entrapment (weight per gallon evaluation);
- Clear glass will be used to maximize reflectance (evaluation of reflectance data); and
- The bactericide and fungicide were at satisfactory levels (odor and viscosity evaluation).

3.1.2 One Hundred-Gallon Formula

| | <u>Percent by Weight</u> |
|--------------------------------------|--------------------------|
| Water | 19.90 |
| Thickeners | 0.50 |
| Dispersing Agent | 0.90 |
| Defoamer | 0.30 |
| Titanium Dioxide | 7.50 |
| Fire Retardant (Aluminum Trihydrate) | 17.70 |
| Hydrated clay | 4.00 |
| Mica | 0.45 |
| Ground Glass (Clear) | 11.00 |
| Elastomeric Emulsion | 36.63 |
| Ammonia | 0.50 |
| Bactericide | 0.30 |
| Fungicide | 0.40 |

3.2 BATCH PRODUCTION AND TESTING

The production batch was completed in July 1995, and yielded 103 gallons. It was packaged in 20 five-gallon pails and three one-gallon pails. The batch was quality control checked and the following test results were found:

| <u>Quality Control Tests</u> | <u>Results</u> |
|------------------------------------|----------------|
| Weight per gallon, lbs. per gallon | 10.48 |
| Viscosity, K.U.'s | 138 |

| | |
|-------------------------|------------|
| Dry time at 12 mils wet | 35 minutes |
| Reflectance | 81 |
| 60 degree gloss | 10 |

3.3 PRODUCTION BATCH APPLICATION

The Able Company was selected to apply the roof coating to the test roof, which was a steel residential roof. The applicator was Karl Miller, who was supplied with 35 gallons of the production batch. His summary of the application is as follows:

“The following recommendations concern application of Eco Coatings' Elastomeric Roof Coating onto a painted steel roof in the greater Seattle area. The roof was scrubbed with soap and a brush, then hosed off and allowed to dry thoroughly. All loose nails were removed and replaced with screws. Facia and trim that overlapped the roof surface was removed. All screw and nail heads were then brushed over to ensure, and aid in, sealing them. The seams between the roof panels were dealt with next.

A 4" wide fiberglass strip was cut the length of the seam. A 6" wide path of roof coating, centered on the seam, was applied with a 3" brush. The mesh strip was laid down and centered on the seam and brushed over with Eco Roof Coating. This process was repeated on all length-wise seams. The vent boots and a metal patch were addressed next using fiberglass mesh cloth. A patch was cut allowing for a generous overlap. Eco Roof Coating was brushed onto the surface, the mesh laid down and more coating brushed on. Care should be taken to remove bubbles, wrinkles, and voids from the mesh cloth. The patches and the coatings were allowed to dry overnight. The first coating was applied with a 4" brush. The second and third coats were applied with a roof coating brush.

This roof is approximately 950 square feet. Thirty-two gallons of Eco Roof Coating were used for the three coats resulting in a total area of 2,850 square feet and a coverage rate of approximately 100 square feet per gallon. All coats were allowed to dry overnight and

were applied when the temperature was above 60 degrees and there was no chance of rain. The product brushed and covered well. Clean up was with soap and water.

A control panel was prepared using the product "Snow Roof"; it was applied on identical metal under the same conditions. The test panel was left on-site to ensure identical exposure."

3.4 PRODUCTION BATCH EXPOSURE TESTING

The test roof will be inspected quarterly and a report will be issued. It will address the following properties that are important in this coating's long term performance:

- Discoloration;
- Cracking;
- Blistering;
- Dirt accumulation; and
- Fungal growth

4.0 RESULTS OF THE RECYCLED GLASS TESTING FOR USE IN COATINGS

4.1 USES

The use of finely ground-recycled glass in waterborne roof coating products has been shown by the accelerated tests on the laboratory samples to be feasible. The glass can be substituted directly on a volume or weight basis for the currently used crushed crystalline silica products. The production batch, which was based on laboratory batch B-1, had excellent flexibility based on its elongation, as reported in Table II. It compares favorably with the Snowroof product in both flexibility and water resistance. The application properties for brushing and rolling of the production batch were excellent according to the contractor's report. Based on these results, ECO coatings plans to pursue further development and distribution of these products.

4.2 RESULTS

This project has shown that crushed and ground recycled glass can be successfully incorporated into coatings. The currently available glass with a size of 100 to 200 mesh will be used in high-thickness coatings (12 to 30 mils dry film thickness), like the roof coating described above. The availability of ground glass in the 325 mesh particle size range would open up the very large potential market (8,000 to 10,000 tons per year) of use in interior flat latex paint.

ACKNOWLEDGEMENTS

CWC is a nonprofit organization providing recycling market development services to both businesses and governments, including tools and technologies to help manufacturers use recycled materials. CWC is the managing partner of the Recycling Technology Assistance Partnership (ReTAP), an affiliate of the national Manufacturing Extension Partnership (MEP) -- a program of the US Commerce Department's National Institute of Standards and Technology. The MEP is a growing nationwide network of extension services to help smaller US manufacturers improve their performance and become more competitive. ReTAP is also sponsored by the US Environmental Protection Agency.

Bailey and Associates, Inc. In August of 1994 Bailey and Associates, Inc. entered into a contract with the Clean Washington Center, a division of the Washington State Department of Community, Trade and Economic Development. Bailey and Associates, Inc. is a coatings consulting firm specializing in paint testing, formula development, analysis of coating failures and inspection of the application of industrial coatings.

Eco Chemical, Inc. The research, development and production of the recycled glass containing roof coating were carried out at the facilities of Eco Chemical Co., Inc., a Washington corporation, located in Seattle, Washington. Eco Chemical develops, produces, distributes, and sells specialty coatings that enhance safe use and reduce negative impact on the environment.

Reichhold Chemical, Inc., Research Triangle Park, North Carolina. This company contributed emulsion binders and formulation advice.

Specialty Polymers, of Woodburn, Oregon. This company also contributed emulsion binders and formulation advice.

Robert Kirby, formerly with the Clean Washington Center. Mr. Kirby contributed valuable information on the sources of crushed and finely ground recycled glass.

Able Company. This company was very cooperative in applying the production batch material to the test roof and supplied photographic and written documentation.

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