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To perform at their best, polymer modified bitumen (PMB) roofing products must have the asphalt dispersed throughout the polymer. There is currently no standard test for the level of dispersion or for the “dispersion grade” in a sample of PMB roofing.

We have developed a guide to measure dispersion. It is based on an amalgam of common industry methods used for PMB quality control before the sheets are coated. This test method, which also can be used to test the dispersion in finished products, was submitted to ASTM International. C.G. Cash attended several meetings where the method was discussed; the method was not approved largely because:

- The manufacturers said they don't need it, since they measure the dispersion before the products are made;
- They alleged that the test was not reproducible; and
- They have some fear that the test data might be used against them.

In this paper, we describe dispersion and include a copy of the guide. Even the critics agree that dispersion is important but correctly point out that there is no single test method that accurately predicts performance on the roof. We argue that our guide to dispersion grading is a useful tool for roofers, investigators, and researchers.

The Dispersion Process

Polymer pellets or powder are added to asphalt in a mixer to create the modified asphalt binder that goes into atactic polypropylene (APP) and styrene-butadiene-styrene (SBS) products. The polymer originally becomes dispersed in the asphalt, absorbing some of the lighter oils and expanding to surround the larger asphalt particles. Later, a “phase inversion” occurs. Instead of particles of polymer in a continuous asphalt matrix, there are now particles of asphalt in a continuous polymer matrix. (If the polymer content is too low, phase inversion will not occur; this low-polymer PMB is more common in pavement.) Further mixing is required to fully disperse the asphalt in the polymer. Filler is added, and the binder is then ready to go to the coater.

Mixture Stability

The polymers used in roofing PMBs generally are not miscible with asphalt. The two components are similar to oil and water. The mixing is a physical process like making mayonnaise. The two phases of the mixture tend to separate and revert to

lower dispersion grades over time, with the PMB's properties falling below viscosity specifications. A stable mixture holds its dispersion for a long time. Accelerated aging tests allow us to observe the long-term dispersion stability of a new product, but they do not (as yet) predict performance. The long-term performance of PMBs is still a topic of needed research.

Factors Determining Dispersion

Many factors determine the dispersion grade of a PMB:

- **Polymer type.** According to some researchers, APP disperses more readily in asphalt than SBS, but APP's dispersion is less stable.
- **Polymer content.** PMB products for roofing should generally contain at least 4% polymer. Products containing more than 7% polymer are easier to mix well, but may be less stable.
- **Asphalt composition and source.** Similar asphalts made from different crude oils may react completely differently to the same polymer.
- **Polymer and asphalt compatibility.** Compatibility is the tendency of a polymer and asphalt to mix well, with a high, stable dispersion grade. Fully incompatible mixes will never reach a high dispersion grade, no matter how long they are mixed.
- **Mixing quality.** The desire for good dispersion must be balanced with the danger of degrading the polymer if it is mixed too long or at too high a temperature.
- **Aging.** As the polymer ages and oxidizes, the stability of the dispersion is reduced and phase separation becomes more extensive.

PMB dispersion grade cannot be predicted from knowledge of the ingredients and the manufacturing process; it must be tested. Manufacturers constantly test the dispersion of their products as part of quality control.

Dispersion Grade Defined

Having good dispersion alone does not ensure high performance. Performance is determined by a multitude of factors, and dispersion is the result of a complex interaction of these factors. Dispersion grade cannot tell the whole story. It is possible to find products with high dispersion grade and poor mechanical properties or durability.

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Designation: D XXXX
**Standard Guide for Estimating the Dispersion of Fluorescing
 Polymer Modifiers in Asphalt**

This test method is issued under the fixed designation D XXXX; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last approval. A subscript epsilon (ϵ) indicates an editorial change since the last revision or approval.

1. Scope

- 1.1 This guide estimates the relative degree of dispersion of a polymer that fluoresces under ultraviolet light, such as atactic polypropylene (APP) and styrene-butadiene-styrene block (SBS) polymers, in asphalt used in polymer modified asphalt roofing products.
- 1.2 *This standard does not purport to address the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*
- 1.3 The values stated in SI units are to be regarded as standard.

2. Summary of Guide

- 2.1 A small quantity of polymer modified asphalt or a vertical section of a polymer modified asphalt coated roofing sheet is examined under a ultraviolet microscope, and the observed dispersion of the asphalt in the polymer modifier is compared to five levels of dispersion described in this guide.

3. Significance and Use

- 3.1 This guide enables the user to quantify the degree of dispersion of fluorescent polymers in asphalt. When first mixed, the polymers blend with the asphalt. This appears in the microscope as fluorescent areas in a background of black asphalt. Additional mixing results in phase inversion, which appear under the ultraviolet microscope as black asphalt areas on a fluorescent polymer background. Complete dispersion appears as black asphalt dots on a fluorescent polymer background.
- 3.2 Proper dispersion is required to maximize the physical properties and stability of the mixture.

4. Apparatus

- 4.1 *Microscope*—Stereo-microscope with an ultraviolet light source.
 Note 1—Nikon Labophot with Micoflex AFX photomicrographic attachment and Episcopic-Fluorescence Attachment EF-D and B-3A filter have been found to be effective.
- 4.2 *Electric hot plate*—A metal surfaced, electric resistance heated hot plate, capable of maintaining a temperature of $200\pm 10^{\circ}\text{C}$ ($392\pm 18^{\circ}\text{F}$).
- 4.3 *Microscope Slides*—Glass microscope slides to fit the stage of the microscope.

5. Procedure

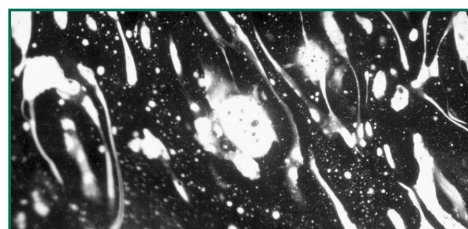
- 5.1 *Polymer Modified Asphalt Coated Products*—Use a razor knife or similar sharp cutter to slice five thin vertical cross section specimens from the sample. To preserve your blade, remove granule surfacing prior to sectioning.
- 5.2 *Polymer Modified Asphalt Melt*—Carefully heat a small quantity of polymer modified asphalt or the thin specimens cut in 5.1 (cut face down) on a microscope slide

preheated to $200\pm 10^{\circ}\text{C}$ ($392\pm 18^{\circ}\text{F}$) on a hot-plate until the bitumen just starts to melt. Remove the slide from the hot plate, and allow the slide to cool to room temperature.

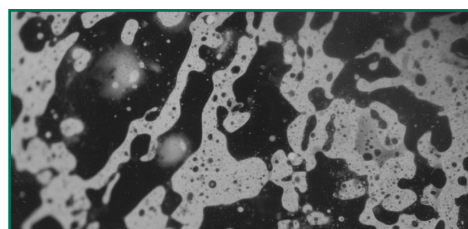
- 5.3 *Alternative Sample Preparation*—Some users prefer to freeze a specimen with CO_2 (carbon dioxide) and quickly snap the sample. Other users prefer to melt a section on a glass slide and examine the dispersion through the glass. The sample preparation technique can result in significant differences in the dispersion observed.
- 5.4 *Microscopic Examination*—Using $100\pm$ x power, photomicrograph at least five representative views of each of the specimens tested.

6. Evaluation

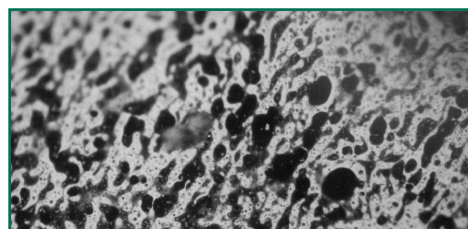
- 6.1 With the aid of the following photographs and descriptions, evaluate the degree of dispersion observed.



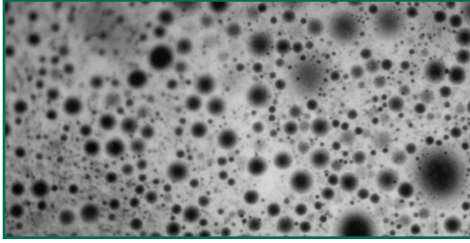
6.1.1 *Grade 1*.—Small, bright fluorescent spots of polymer on a black field. The polymer has not yet begun to swell and incorporate asphalt.



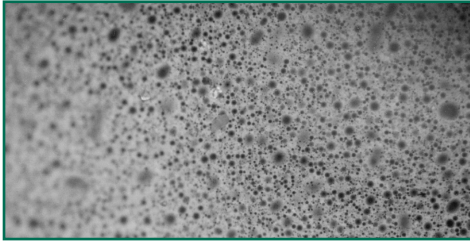
6.1.2 *Grade 2*.—Solid black asphalt areas begin to break up. Fluorescent areas appear larger and darker, sometimes with small dots of asphalt in them.



6.1.3 *Grade 3*.—Phase inversion. View is black on fluorescent polymer.



6.1.4 *Grade 4.*—Irregular black asphalt areas on a yellow field. Asphalt dots lack uniformity.



6.1.5 *Grade 5.*—Small, relatively uniform black asphalt dots suspended in a fluorescent polymer field.

7. Report

7.1 Completely identify the sample, the preparation method, the average and standard deviation of the ratings from each sample, the name of the laboratory, and the individual conducting the work. Include with the report the sample preparation, the magnification used, and a print of each photomicrograph.

8. Precision and Bias

8.1 *Precision*—The procedure in Test Method D XXXX for measuring the dispersion of asphalt in fluorescent polymers has no bias because the dispersion is defined only in terms of this method.

9. Keywords

APP, asphalt, asphalt roofing, atactic polypropylene, dispersion, phase inversion, polymer modified asphalt, roofing, SBS, styrene-butadiene-styrene.

However, poor dispersion does ensure poor performance. In one case, it was found that a brand-new APP multi-ply membrane was so soft and inelastic that people walking on the roof left footprints. Upon testing, the material was found to have a low dispersion grade, indicating that either the mixture was badly prepared or that it contained incompatible materials. While dispersion grade cannot guarantee that a PMB product is suitable, it can warn the contractor or investigator that a product is unsuitable.

The Need for Uniform Dispersion Grading

Currently, most roofing manufacturers have their own in-house testing procedure for dispersion. The industry lacks a standard way to compare the dispersion grades of different manufacturers' products. Additionally, roofing professionals may simply be unaware of the ease of testing directly for dispersion grade. The dispersion estimation guide can fill this gap.

Using the Guide

Dispersion of polymers in asphalt is not yet fully understood, so the test method described in the guide cannot be used to predict real-world performance, especially over time. The test uses qualitative optical grading, so two operators may grade the same sample differently. Also, results may vary due to different specimen preparation procedures. But in 1998, round robin testing by 12 different labs showed the precision of this test to be plus or minus one grade. This should allow confident determination of whether a specimen shows adequate dispersion and whether one specimen has better dispersion than another.

The guide allows us to objectively compare the dispersion

levels of different manufacturers' products and provides a convenient common grading system for future dispersion research. ■

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Joe Cua is a co-op student working in Simpson Gumpertz & Heger's Boston office. He is attending Cornell University in New York and will be completing his B.S. in Civil and Environmental Engineering.

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During his more than 40 years of experience in the roofing industry, Carl has worked in research, product development, manufacturing, quality control, marketing, and sales. Carl is past chairman for ASTM Committee D-08 on Roofing, Waterproofing, and Bituminous Materials. His last 25 years have been devoted to consulting, solving problems for clients, and using the information obtained to try to prevent problem recurrence.



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