Rubber manufacturers suggest weathering tests for EPDM roofing

There has been general consensus about what test methods and physical properties are necessary for high-quality EPDM rubber sheets in the domestic market. The only exception to this is a test requirement for ultraviolet (UV) resistance. The Rubber Manufacturers Association (RMA) Roofing Council agreed to provide the time and funding to study the UV weathering resistance of EPDM by establishing a weathering test program in February 1984. The RMA Roofing Technical Committee was charged with the responsibility of establishing and monitoring the program with the following objectives:

- to establish a correlation between indoor and outdoor weathering tests;
- to develop a recommendation for a proposed weathering test to be specified in industry standards, based on results obtained; and
- to relate the results of indoor and outdoor weathering tests with known experience of a reference material.

The results of the weathering test program for black EPDM were conclusive and the objectives of the test program were met. Correlation was established for black EPDM rubber sheets between laboratory weathering tests and outdoor Florida weathering. The weathering test program results for white EPDM were not as conclusive as for black, and additional program work is planned.

Samples are selected and prepared

The members of the Roofing Technical Committee that market EPDM sheets were asked to submit *unidentified* samples of commercially available, non-fabric reinforced membrane. From all of the submitted sheets, one black and one white EPDM membrane were randomly chosen for testing and are henceforth referred to only as "black" and "white."

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Another black EPDM sheet, used as a control, was made from a known formulation with a 20-year history of proven weather performance. In the referenced study, this control-based formulation was exposed to Florida 45 degree south outdoor exposure under no strain for 20 years starting in 1961, with physical properties determined every five years. The sample made from this control formulation is henceforth referred to only as "control."

The white, black and control samples were cut into specimens for weathering exposure. The specimen size was approximately 2-by-8-inches or 2-by-12-inches, depending on the weather exposure apparatus. The lengthwise direction of the specimen was parallel to the machine-processing direction of the sample. Either 2-inch- or 4-inch-wide benchmarks were placed on each specimen to allow precise measurement of the 50 percent elongation (strain) under which half the specimens were to be exposed.

The specimens for outdoor weathering were mounted on kilndried white oak boards, while the specimens for laboratory weathering were mounted on exterior-grade plywood covered with aluminum foil. The specimens were divided into two groups: one group was mounted under no strain (0 percent elongation), and the other group was mounted with 50 percent strain (50 percent elongation).

Four types of exposure used

The mounted specimens were exposed to four types of weather/UV exposure: a xenon-arc weathering apparatus, a fluorescent UV-condensation apparatus, South Florida direct inland weathering, and concentrated natural sunlight.

The specimens were inspected after each exposure period for general appearance, chalking, cracking and crazing. Tensile strength and ultimate elongation were measured using ASTM Test Method D412. The tear resistance was also measured, but these values did not decrease with weather exposure until severe deterioration occurred with the white specimens.

The black and control specimens had very similar PRFSE curves for outdoor and laboratory weathering.

The approach selected to evaluate the physical property changes after weathering is the percent retained fractional strain energy (PRFSE). The fractional strain energy is a measure of the aged tensile strength and elongation compared to the original tensile strength and elongation.

The specimens were inspected under no magnification after each exposure period. The black and control specimens did not show any indication of surface deterioration by either cracking, crazing or chalking while examined unstrained. However, very slight cracking was seen on the control exposed under 50 percent strain after 3,500 hours of xenon-arc exposure. The white specimens began to chalk early in the program with crazing becoming more pronounced as the exposure periods increased. The xenon-arc and Florida 45 degree south exposures produced the greatest amount of surface deterioration in the white specimens (chalking and crazing), with the fluorescent UV-condensation exposure producing chalking and crazing to a lesser extent. Concentrated natural sunlight produced chalking but no crazing on the white specimens.

Discussion and conclusions

Single-ply polymer-based sheets, including the rubbers and thermoplastics, must be properly formulated to withstand the degrading effects of weathering, particularly from UV radiation. Resistance to UV deterioration is not an intrinsic property of the polymers used in the roof sheet; the polymer must be protected by the judicious selection of UV-absorptive compounding ingredients. It is most important to select weathering tests that identify any deficiencies that the sheet may have to long-term weather resistance.

It is possible to note some general conclusions or trends that are evident from the exposure data:

- After extended aging, the EPDM sheet tensile strength and elongation (and, therefore, its fractional strain energy) is reduced, but its tensile strength and elongation indicate the potential for additional years of useful service life.
- Relatively short weather exposure can actually increase the membrane's retained fractional strain energy, perhaps by increasing the membrane's state of cure.
- Florida 45 degree south exposure is more severe than concentrated natural sunlight for either equivalent total solar radiation or the UV portion of the total radiation. Concentrated natural sunlight has the advantage, though, for accelerated UV testing because the specimen is exposed to more radiation per unit of time.
- The specimens exposed to Florida 45 degree south weathering under 50 percent strain had lower retained fractional strain energy than those exposed to Florida 45 degree south under no strain. The differential between 50 percent strain and no strain is less pronounced for the other weathering tests.
- Xenon-arc and fluorescent UV-condensation caused essentially comparable reductions in retained fractional strain energy.
- Surface deterioration after weathering of the white specimens was much greater than that of the black and control specimens. Crazing and chalking occurred during Florida 45 degree south, xenon-arc and fluorescent UV-condensation on the white specimens. However, the temperatures used in the fluorescent UV-condensation test were higher than rooftop temperatures for white membranes, and this may be too severe a test to evaluate long-term weathering characteristics.
- The black and control specimens had very similar PRFSE curves for outdoor and laboratory weathering. The prediction can be made that the black specimen would have similar aging characteristics as the control specimen on the 20-year Florida exposure.
- Comparing the PRFSE curves for the control for the 20-year Florida exposure with those of the fluorescent UV-condensation and xenon-arc shows the 4,000-hour PRFSE values to be comparable to the 15-year mark of the Florida exposure.

Recommendations

The correlation of real-time weathering to short-term accelerated weather testing has been and will continue to be a topic for study and debate; however, the technology and equipment does exist to determine the general weather resistance of EPDM rubber sheets.

The RMA Roofing Technical Committee recommends that the xenon-arc weathering apparatus (ASTM G26) and the fluorescent UV-condensation apparatus (ASTM G53) for black EPDM sheets be used in industry standards. The following pass/fail criteria should also be used:

- Visual inspection shall show no cracks or crazing.
- The PRFSE shall be a minimum of 30, and the aged ultimate elongation shall be a minimum of 200 percent.