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It Came From Hail

Tom Hutchinson and Jim D. Koontz

Tests show how certain roofs hold up to hail storms.

The roof is becoming a more complex, challenging, and important component of any number of buildings, but especially so for schools and universities. The current economic climate, the growing presence of energy producing systems (solar panels or wind turbines), the increased usage of vegetative roofing, and the desire to improve the sustainability and life cycle of a roof system are just some of the key factors that must be considered, along with the usual questions of cost and value.

With regard to sustainability, it is important to know as much as possible about how a roof system, and the individual components in it, will perform upon installation and how it will maintain that performance for a significant period of time and under a variety of conditions. Those conditions include extreme weather: heat, cold, wind, and rain.

For a wide portion of the country, hail presents an additional weather challenge, one that can be extremely costly. Hail damage to roof assemblies within the United States and worldwide results in millions of dollars of economic loss each year.

Clearly, a hail-resistant roof system can save building owners a large amount of money. The members of the EPDM Roofing Association (ERA) knew from empirical experience that EPDM roof systems faired very well in hailstorm events.

However, ERA desired scientific validation of EPDM's high level of performance in hail events on roofs that have been in place for a number of years and have been exposed to weathering. In spring 2008, it embarked on a hail testing program and contracted with Jim D. Koontz & Associates, Inc., (JKA) of Hobbs, NM, to conduct controlled testing of the hail resistance performance of EPDM.

JKA provides laboratory testing of all types of roofing materials and is actively involved in research of roofing materials and assists in the development of testing standards. Because of its expertise in roof material testing, roof system analysis, and specific experience with EPDM, ERA felt JKA would be able to provide an independent source of testing and the necessary expertise to evaluate the testing results.

The ERA technical committee decided that the most useful test would determine the performance of aged, insitu EPDM, along with new and artificially heat-aged material. Carlisle SynTec Inc. and Firestone Building Products each provided four-ft. by four-ft. new 60-mil EPDM material samples, had new 60-mil EPDM material heat-aged, and procured 60-mil samples from roof covers that have been exposed from between five and 15 years.

Preparation for Testing

Field experience from the examination of thousands of roofs has clearly shown that hail damage to a roofing system can be the result of several factors: diameter of the hail, type of roofing system, age of the roof cover, substrate beneath the primary roof system, and surface temperature at the point of impact. To evaluate a roofing systems resistance to hail damage, these reference points have to be considered as part of a research project.

Prior to sending the EPDM samples for testing, the EPDM material was fully adhered to various four-ft. by four-ft substrates: mechanically fastened polyisocyanurate insulation, mechanically fastened wood fiberboard, and 1/2-in. plywood. Between 20 and 35 samples of each roof cover category were sent for testing.

Historically, the hail resistance of roofing products has been tested by dropping steel balls or darts on to the roofing product at room temperature. Within the last few years, however, greater consideration has been given to impacting targets with ice spheres, including research conducted by JKA. The use of ice spheres, obviously, comes closer to replicating what occurs during a real hailstorm event.

Also, in order to produce a more realistic environment for testing, JKA has reached the conclusion that targets should not always be placed at room temperature during testing. Hailstorms are often accompanied by severe thunderstorms with rainwater that is substantially lower in temperature than the ambient air temperature. JKA has incorporated into much of its testing a system that allows the material being tested to be "chilled" by running water during the process.

JKA believes this produces a more realistic temperature to determine the results of the testing and, in this test, decided to use ice spheres to be propelled against membrane with running water flowing over it.

Test Methods

A key factor in performing the test is to have reproducible impact energies with each shot of "hail." The hail gun propels ice spheres by using the quick release of compressed air from a tank to a barrel. In order to achieve reproducibility, consistent "air pressure" is required for each shot. This necessitates controlling the air pressure to 0.01 psi.

Molds for ice spheres are fabricated using precise diameter steel spheres. Each ice sphere of a given diameter is then weighed to .01 grams prior to each shot. Laboratory grade barrels or tubes with precise internal diameters are also necessary to develop consistent impact energies. Basically, the charge, i.e., air pressure, the quick-release valve, and the bullets (ice spheres), require precise fabrication in order to achieve reproducible impact energies.

The ice spheres are initially weighed and then placed in the barrel, similar to a lead shot for a muzzleloader. As the ice sphere is pneumatically launched towards the target, the velocity is measured with a ballistics timer. The kinetic energy or "impact energy" is then calculated for each hail shot. The minimum kinetic energies listed by the National Bureau of Standard (NBS) are maintained within a tolerance of plus zero plus 10 percent.

Carlisle and Firestone provided a total of 81 test targets constructed with 60-mil non-reinforced EPDM for impact testing — 25 new test targets, 20 that were heat-aged, and 36 that were field-aged. The field-aged and exposed EPDM samples were collected from six states across the country (Indiana, Kansas, Colorado, Nebraska, Utah, and Iowa) and ranged in age from five to 20 years.

The artificially heat aged samples were prepared at Cascade Technical Services of Hillsboro, OR. The samples were heat aged for 1,440 hours at a temperature of 240 degrees F.

The four-ft. by four-ft EPDM "targets" were installed over a variety of substrates that included polyisocyanurate and woodfiber insulation, plywood, and OSB board. Fully adhered EPDM was used in the target construction; refer to the following table.

Roof Targets

Material Age	Substrate	Sample Number
New	1.75-in. Polyisocyanurate	3
New	2-in. Polyisocyanurate	4
New	½-in. OSB 2.0-in. Polyisocyanurate	7
New	2.0-in. Polyisocyanurate Neoprene cover at fastener head	5
New	½ -in. Wood Fiber 2.0-in. Polyisocyanurate	6
Heat Aged	½-in. Wood Fiber 2.0-in. Polyisocyanurate	6
Heat Aged	½-in. Plywood 2.0-in. Polyisocyanurate	3
Heat Aged	½-in. OSB 2.0-in. Polyisocyanurate	3
Heat Aged	2.0-in. Polyisocyanurate	8
Field Aged	2.0-in. Polyisocyanurate	18
Field Aged	½ -in. OSB 1.5-in. Polyisocyanurate	18

Each target with substrate was mounted vertically. Hailstones measuring 1.5 in., two in., 2.5 in., and three in. impacted the targets at a 90-degree angle at velocities listed by the NBS. In order to replicate severe weather conditions — cold rain during a hailstorm — the test targets were sprayed with water at 40.

The various targets were impacted both in the "field area" and also directly over fasteners and plates used to secure the substrate below the EPDM. Failure was defined as a visible split or cut in the surface of the EPDM.

Test Results

Of the 25 "New" EPDM test targets tested, 24 targets were not damaged by three-in. hail balls. None of the 20 "heat-aged" targets failed when impacted with three-in. hail balls.

The "field-aged" EPDM target samples included 18 over a two-in.-thick polyisocyanurate insulation substrate and 18 over a 1/2-in.-thick OSB substrate, supported by 1½-in.-thick polyisocyanurate roof insulation. Fourteen of the EPDM targets that were adhered directly over the polyisocyanurate did not fail when impacted with three-in. hail balls. One sample failed with a three-in. hail ball and a second sample failed with a 2.5-in. hail ball. None of the 18 EPDM "field-aged" targets over OSB were damaged by three-in. diameter hail balls. Refer to the following table.

Roof Samples' Results

Material Age	Substrate	Samples Passed
New	1.75-in. Polyisocyanurate	3
New	2-in. Polyisocyanurate	4
New	½-in. OSB 2.0-in. Polyisocyanurate	6 of 7
New	2.0-in. Polyisocyanurate Neoprene cover at fastener head	5
New	½ -in. Wood Fiber 2.0-in. Polyisocyanurate	6
Heat Aged	½-in. Wood Fiber 2.0-in. Polyisocyanurate	6
Heat Aged	½-in. Plywood 2.0-in. Polyisocyanurate	3
Heat Aged	½-in. OSB 2.0-in. Polyisocyanurate	3
Heat Aged	2.0-in. Polyisocyanurate	8
Field Aged	2.0-in. Polyisocyanurate	14 of 18
Field Aged	½ -in. OSB 1.5-in. Polyisocyanurate	18

The new, heat-aged, and field-aged non-reinforced EPDM tested within this study provided excellent resistance to large hail. Of the 81 targets installed over polyisocyanurate, wood fiber, plywood, and OSB board, 76 did not fail when impacted with hail up to three in. in diameter.

The overall test results clearly indicate that non-reinforced EPDM roof assemblies offer a high degree of hail resistance over a variety of substrates. Perhaps most importantly, the impact resistance of both the field-aged and heat-aged membrane in this test also clearly demonstrates that EPDM retains the bulk of its impact resistance as it ages.

These test results provide cogent data for the consideration of building professionals interested in the long-term performance in their roof systems. This is especially important to those dealing with critical facilities such as schools. The use of non-reinforced EPDM can provide a valuable additional level of long-term protection. SPM

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