Winter 2020

CAD NEWS®

A publication of the Color and Appearance Division of the Society of Plastics Engineers

Chairman's Message

Hoping this winter edition of the CADNEWS® finds everyone doing well! It is difficult to begin without acknowledging the ongoing COVID pandemic as it seems to have brought a new normal to our everyday lives as we go into the holiday season. I hope you and your families were able to have a happy Thanksgiving albeit most likely smaller and quieter than normal. I know mine was which gave me more time to reflect on reasons to be thankful beginning with a successful Virtual RETEC®.

This was the first virtual RETEC® and required a tremendous amount of effort in a short period of time. A big thank you for the leadership of Jeff Drusda and Cheryl Treat and the volunteers of the CAD RETEC® committee in organizing our first virtual conference. Having a strong emphasis on education, it was gratifying to receive favorable feedback on the technical content and quality of the presentations. Thank you, Mark Tyler, Alex Prosapio, and all presenters for a job well done! Scott Heitzman championed the New Technology Forum which was well attended once again. We also continued the traditional Fun Run benefiting Habitat for Humanity with a virtual rendition and CAD once again matched the donations. We are also grateful for company sponsors and their immeasurable impact on the sustainability of RETEC®. Thank you, Ed Ford, and Scott Aumann, for organizing sponsorships. The closing raffle was a success thanks to Chuck Depew and over thirty donations made by twenty-five different companies.

An outstanding team effort along with support from SPE made virtual RETEC® possible; however, I think it's safe to say we all missed the personal interaction and are hopeful that RETEC® 2021 will be a live event in Atlanta September 19-21st. Betty Puckerin, Elizabeth Serdar, and Kimberly Williamson are already hard at work as RETEC® 2021 Chairpersons. For those interested in presenting papers TJ Stubbs, Alex Prosapio, and Andrew Smith will be organizing the technical program.

ANTEC® 2021 is currently scheduled to be a hybrid event being live in Denver March 22-23rd with technical session live streaming March 29th thru April 9th. Please stay tuned and check the website for additional info and updates.

The next CAD BOD meeting will be virtual and is scheduled for January 12th, 2021. Active SPE CAD members are welcome to join the meeting. If you are interested, please let me know.

COVID most likely means altered holiday season plans and smaller or even canceled family/social gatherings. Changes such as these may make it more difficult to capture the spirit of the season. A dose of patience and gratitude may be the answer. On behalf of the CAD BOD I would like to wish everyone happy holidays and a healthy and prosperous New Year!

Mark Freshwater
2020-2021 Chair
Color and Appearance Division

SPE COLOR & APPEARANCE

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Editor's Note

Welcome to the Winter Issue of CADNEWS®, the last CAD Newsletter of 2020. What a year 2020 turned out to be. Consider going back the Winter Issue of 2019 and looking at the previews of all the exciting events for 2020, then how everything came to screaming halt in March. It is amazing what we have been through. So many negative curveballs have been hurled at us, and yet there were a lot good people stepping up to the plate as we learned to cope and adjust to the new normal. ANTEC® went to a full-on Virtual event within three weeks of the live event. Many other events went to the Virtual format throughout the year including our very own virtual CAD RETEC ®2020. CAD Board of Directors and SPE worked tirelessly to put the virtual event together and in accordance with the tag line, I believe we did make a Splash.

All and all, the event was a success and a lot was learned about our Division with their commitment and support. A big thank you to all who attended, sponsored and exhibited to the 2020 CAD Virtual RETEC®

As we close this unprecedented year of 2020, we can start to look forward to 2021 and what will be happening. ANTEC® 2021 will be in Denver, Colorado, during March 22nd and 23rd for the live event and will have virtual real-time presentations during March 29th through April 9th. CADRETEC® 2021 will be in Atlanta, Georgia, on September 19th to 21st. It will run from Sunday following with technical programs all day Monday and Tuesday so save the date now. Scholarship opportunities will be available for the 2021/2022 school year. Please see the information on the bottom of page 4 in this newsletter on how to obtain information on these scholarship opportunities.

Last but not least, please let us know your interest in sponsoring CADNEWS® with an ad for your company. These sponsorship ads allow us to produce these newsletters and help maintain a solvent Division of the SPE therefore allowing us to keep getting pertinent information out to the division members. See the page 19 in this Newsletter that shows the different sizes available and contact information. Ads will run from Spring issue in March through the Winter issue in December. We guarantee a minimum of three issues being published per term, but for the last three years we have been able to produce four a year. We would need to know your interest by the end of January and your sponsorship ad soon afterwards.

Hopefully, there is something of value to you in the Newsletter and as always if you have any suggestions or comments please contact me or let someone on the BOD know what that may be.

Mark Tyler
Newsletter Editor
tylerm@xxxsilberline.com

Milliken introduces KeyPlast RESIST™: A spectrum of bright, high-performance colorants for engineering plastics

New portfolio designed specifically for coloring polyamides and high-heat engineering plastics

Milliken & Company, recognized as a worldwide leader of plastic additives and colorants, announced the launch of KeyPlast RESIST™, a spectrum of bright, high-performance colorants for engineering plastics.

Polyamide resins and high-heat engineering polymers present unique challenges in the world of plastics. The materials of choice in demanding electrical, automotive and industrial applications, polyamide resins and high-heat engineering polymers are subject to high-temperature processing and require steady, reliable performance properties, making vibrancy of color difficult to achieve.

Milliken has addressed this challenge with its KeyPlast RESIST range of colorants. These products are specially designed for coloring engineering polymers such as polyamides, polyimides, PBT polysulfones, PEEK, PPO and other high-heat resins and alloys. KeyPlast RESIST colorants can be used effectively with unfilled, glass-filled, and flame-retardant grades of various polyamide types such as polyamide 6, 66, 46, and other high temperature engineering polymers.

"Keyplast RESIST meets the strong requirements in another fast-growing application area—that of electrical vehicles and their charging system requirements," said Sami T.K. Palanisami, Milliken Global Product Line Manager, Plastic Colorants.

The new range delivers the brilliant, consistent colors — including bright orange, yellow, red, blue and green—and the high-end properties that users demand. These colorants offer improved weather resistance and light fastness, are high purity and perform well in the high-temperature and chemically-reductive conditions typically associated with high-performance polymers.

Milliken introduces KeyPlast RESIST™: A spectrum of bright, high-performance colorants for engineering plastics. (Photos © 2020 Milliken & Company, all rights reserved, MKPR209)

For more details and information please contact us or visit us online at ***chemical.milliken.com***

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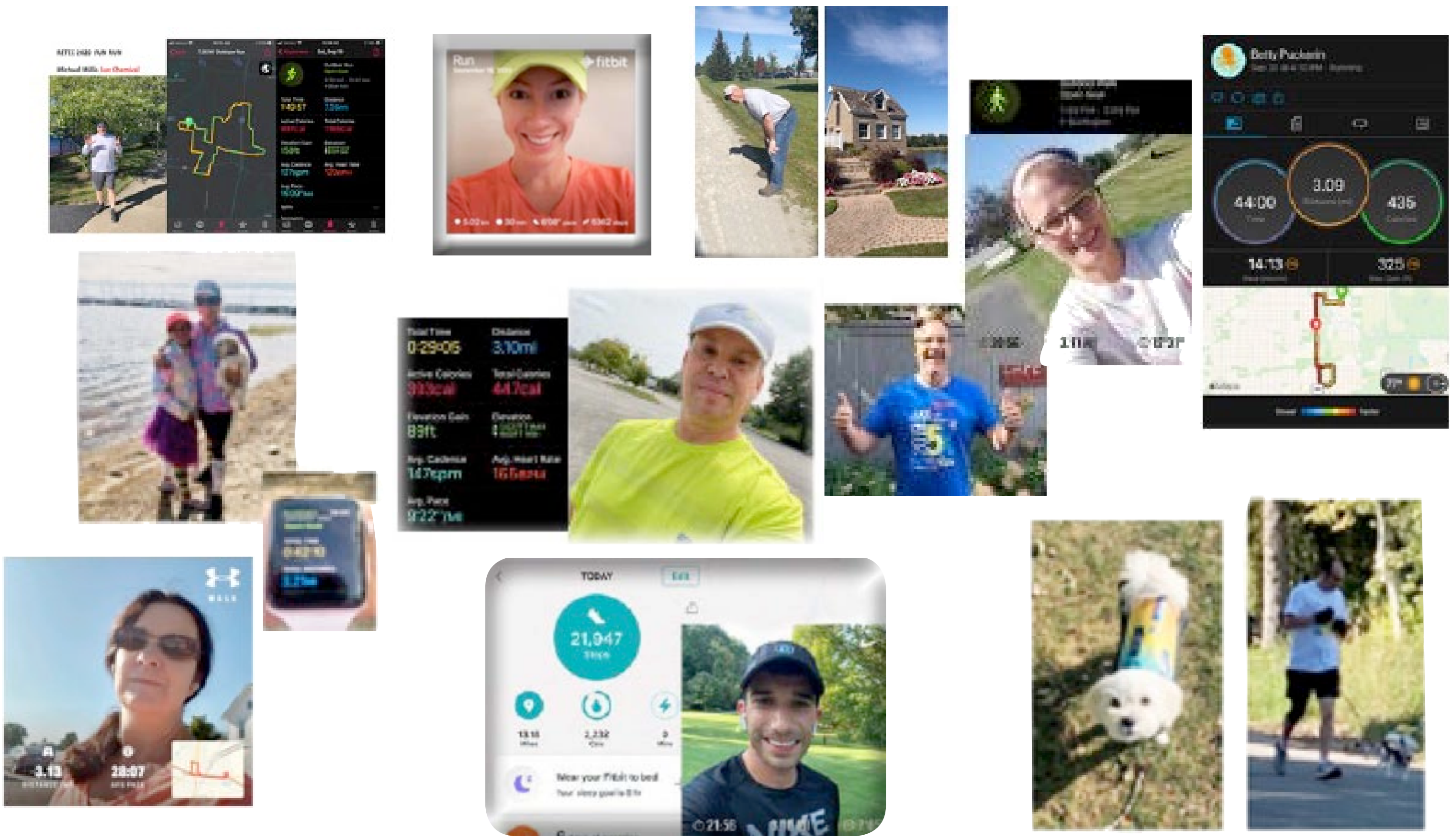
CAD RETEC® 2020 Virtual Fun Run *(14th Annual 5K)*

Fun Run
Sponsored by: DCL

SPE CAD RETEC® has been supporting Habitat for Humanity (HfH) since 2005 when Hurricane Katrina struck the Gulf Coast causing catastrophic damage from central Florida to eastern Texas.

Since then, the SPE & DCL Corporation (Formerly "Dominion Colour Corporation" & "LANSCO Colors") have supported the Habitat for Humanity in their mission to bring people together to build homes, communities and raise hope through sponsorship of the 5K Fun Run.

DCL wanted to keep the tradition alive this year, despite SPE CAD RETEC® going virtual. They were able to raise $700 for the Habitat for Humanity Greater Orlando Region. We would like to extend a huge thank you to everyone who participated and/or donated! If you would like to contact Kathyrn Farr at HfH Orlando regarding any type of contribution, please feel free to reach out: KFarr@habitatorlandoosceola.org.



CAD Scholarship Opportunity

This is an SPE CAD Scholarship Information Reminder for the 2021/2022 School Year. The Society of Plastics Engineers Color and Appearance Division have scholarships available for qualified individuals.

Each year, scholarships are awarded in honor of some of those who have influenced our industry through education of up to $4,000 each. Additional full or partial scholarships may be awarded based on available funding and on the number of qualified applicants.

Jack Graff Memorial Scholarship	up to $4000.00
Bob Charvat Memorial Scholarship	up to $4000.00
George Rangos Memorial Scholarship	up to $4000.00
Gary Beebe Memorial Scholarship	up to $4000.00
Steve Goldstein Memorial Scholarship	up to $4000.00

For questions on applications or process please email Ann Smeltzer, or call her at 412-298-4373

Color On My Mind

CAD RETEC® 2021

spe CAD RETEC®
Atlanta, Georgia • September 19-22, 2021
Presented by SPE Color and Appearance Division

Call For Papers

Save the Date: September 19th – 21st, 2021

YOU ARE INVITED TO SUBMIT A PAPER FOR PUBLICATION & PRESENTATION
Venue: Marriott Marquis • Atlanta, Georgia

Chairperson:	Betty Puckerin, Ampacet Corporation betty.puckerin@ampacet.com	
Vice Chairperson:	Elizabeth Serdar elizabeth.serder@omya.com	
Vice Chairperson:	Kimberly Williamson, Techmer PM kwilliamson@techmerpm.com	
Technical Program:	Alex Prosapio, Sudarshan, AProsapio@sudarshan.com	TJ Stubbs, Teknor Apex tstubbs@teknorapex.com

2020 Terry Golding Outstanding Achievement Award

Submitted by Doreen Becker

Awardee: Ann Smeltzer

Ann has been a pillar of strength and strategy on the CAD board since she was first elected to the board in 2005. Her tireless contributions to the Endowment committee focused on the CAD scholarship process and the chair positions that she has held throughout the years has contributed greatly to the successes of the Color and Appearance Division for many years.

Ann also has co-chaired the CAD technical programs twice for ANTEC® and RETEC®.

Ann has always held a unique position on our board since she holds a business degree from Purdue University and an MBA from University of Pittsburgh but has devoted the bulk of her career to the color industry for plastics. CAD has really benefited from her business acumen and her expertise in marketing and has greatly strengthened CAD's position as a leading SPE division as well as positioning this group as a global authority in the coloring of plastics. As a technical organization, sometimes we overlook the importance of the business side of our industry, but Ann has always been a voice of balance and clarity.

She has also been a champion of our Scholarship process. As the chair of the Endowment committee, she always fights for her students who need these scholarships to continue their education. She seems to have a personal connection with the students and frequently speaks warmly to the board about them almost like they are her own. Ann has organized and grown this committee into one of our most cherished components of our outreach program.

In her role as Chair of the Color & Appearance Division and all of the roles she participated in the executive committee, Ann has exhibited exemplary leadership and mentoring skills, solid authority and discretion tempered by a great sense of humor and an easy smile.

Problems and Solutions for Coloring High Heat Polymers

Growth of the plastics industry depends on finding performance polymers that can replace traditional substrates and provide better performance, lower cost, extended durability or reduced weight. These performance polymers are generally processed for several minutes at temperatures in excess of 550°F (288°C), and therefore, require colorants that are equally heat stable. However, many organic pigments and solvent dyes degrade, sublimate, or migrate at these elevated temperatures. To further complicate matters, the amides in nylon react with many organic colorants. This reaction causes the chromphore to degrade, thus leaving very few options to color high performance high temperature polymers.

Seeing this problem, ColorChem has developed and commercialized a solution—a full line of heat resistant dyes specifically engineered for glass-filled nylon, polysulfones and other high heat polymer applications. Testing and commercial usage has shown that ColorChem's Amaplast® high heat dyes can withstand the elevated processing temperatures and extended dwell times that cause other colorants to degrade. These Amaplast® dyes provide the brightest hues on the market, and will not react with nylon, thereby maintaining their color and clarity throughout multiple processing cycles.

ColorChem's dyes are ideal for coloring all nylons and glass-filled nylons, polysulfones, PC, and PEEK. ColorChem's technology is proven, proprietary and domestically manufactured. Amaplast® dyes outperform the commercial alternatives offered by offshore manufacturers, such as Solvent Orange 116, Solvent Red 52, Solvent Red 149, Solvent Yellow 104 and Solvent Blue 7.

As a domestic manufacturer, ColorChem has complete control over the manufacturing process, purity, inputs, supply chain, and logistics, for these products.

ColorChem's high heat colorants include the following products:

- Amaplast® Yellow NX: a bright neutral yellow
- Amaplast® Orange YXL: a bright orange
- Amaplast® Orange GXP: a bright red-shade orange
- Amaplast® Blue HB: a strong blue
- Amaplast® Violet PK: a strong violet
- Amaplast® Red BSR: a blue-shade red (not suitable for polyamide)

In addition, ColorChem offers cerium sulfide based pigments for use in opacifying and coloring nylon and other high heat polymers. These pigments, now known as Greentop™ and Neolor™ pigments, can be used in conjunction with ColorChem's Amaplast® dyes to color the most demanding polymer applications and the combination is especially suitable for use in coloring glass-filled nylons.

The GreenTop™ and Neolor™ products, for which ColorChem is the exclusive U.S. distributor:

- Neolor™ Light Orange H
- GreenTop™ Orange S
- GreenTop™ Red S

With the addition of the Greentop™ and Neolor™ pigments, ColorChem is a one-stop shop for high heat coloring solutions.

Please visit www.colorchem.com, or contact ColorChem directly at +1-770-993-5500 or sales@colorchem.com for additional regulatory or product information.

The SPE Color and Appearance Division generously donated $35,000 to PlastiVan® in 2019. Combined with their 2018 gift of $17,500, their support over two years of $52,500 provided a PlastiVan® visit to 30 classrooms, bringing the exciting world of plastics to thousands of students. Thank you, Color and Appearance Division, for this meaningful impact toward changing the perception of plastics one classroom at a time. And a big THANK YOU for committing to another $35,000 for 2020!

spe COLOR & APPEARANCE

PlastiVan®

PLASTIVAN®: CHANGING THE PERCEPTION OF PLASTICS ONE CLASSROOM AT A TIME

Through lively demonstrations and hands-on activities, the PlastiVan® Program is designed to excite students about opportunities in science and engineering within the plastics industry. Students are educated about the chemistry, history, processing, manufacturing, and sustainability of plastics and how the science and real-world applications relate to their everyday lives. PlastiVan® provides sound science and educational programs which spark scientific curiosity in students while increasing their knowledge of the contribution plastics make to modern life; encouraging them to seek careers in engineering.

PlastiVan® educators are skilled in tailoring the presentation to meet the needs and grade-level expectations of each classroom and teacher. The program is easily integrated into school curricula. A PlastiVan® visit typically consists of 5 classes/day for up to 40 students/class or is individually designed for STEM and science fairs.

Click here for more information on the PlastiVan®

ANTEC® 2021 Denver
Sunday, March 21, 2021 - Thursday, March 25, 2021 - All Day
Sheraton Denver Downtown, Denver, Colorado

ANTEC® Industry Insights   March 22–23, 2021
Kicking off ANTEC® 2021, must-hear plastics leaders will share their valuable industry insights. Join us for this two-day event via SPE's exclusive live-streaming service to your remote location.

ANTEC® Classic   March 29-April 9, 2021
ANTEC® Classic, slated for March 29 to April 9, will offer real-time, remote presentations occurring over 10-days with 20 technical tracks. Additionally, it will include International Spotlights with real-time global presentations broadcast online from various regions around the world, including Asia, India, Australia/New Zealand, Europe, and the Middle East. Dates for International Spotlights will be forthcoming.

Hear from the industry's top researchers as they discuss their latest findings. In the traditional ANTEC® format, 200+ papers across a wide variety of topics will be presented. Watch the presentations real-time, with Q&A after each presentation, or watch the recorded sessions on-demand on your schedule.

CAD 2019 RETEC® Best Paper

WATER DELIVERY DURING ACCELERATED WEATHERING TESTING FOR IMPROVED CORRELATION TO OUTDOOR RESULTS

Andy Francis, Bill Tobin,, Sean Fowler, David Duecker, Andreas Giehl, and Brad Reis
Q-Lab Corporation, Westlake, OH, USA

Introduction

Weathering testing has been conducted for a very long time, as the earliest accelerated weathering test methods using carbon arc lamps date back over 100 years [1]. Although there are significant differences in the architecture of the apparatuses used to conduct testing, and in the objectives of different tests, all of them deliver the three primary “forces of weathering” to test specimens: light, heat, and water. In doing so, a balance must be struck between the degree of acceleration in testing and the degree of simulation. As illustrated schematically in Fig. 1 below, while increasing the acceleration of weathering testing can shorten test times, this often comes at the expense of correlation to true outdoor weathering results. Considerable effort has gone into developing laboratory weathering tests that provide acceptable correlation to outdoor results while also accelerating the forces of weathering enough to provide sufficiently faster results.

Generally speaking, the primary focus in the development of most accelerated weathering tests has been in defining the light source. Test machines used to conduct laboratory weathering are routinely described by their light source: xenon arc, fluorescent ultraviolet (UV), carbon arc, metal halide, mercury lamp, etc. The tester architecture is often designed around the light source, and a user’s selection of test architecture is often based upon the results that the irradiance from that light is expected to deliver. Two major examples are xenon arc and UV fluorescent testers: Xenon arc lamps deliver an accurate reproduction of full-spectrum sunlight, while fluorescent UV lamps provide the critical shortwave ultraviolet (UV) portion of the solar spectrum. Irradiance is defined carefully and precisely in nearly every major international test standard, with care given to which region of the spectrum is controlled by the test device. Xenon arc testers, for instance, can be controlled over the total ultraviolet (TUV) wideband range (from 300-400 nm), or at a narrowband wavelength of 340 nm or 420 nm. Precise values of irradiance (60 W/m2 TUV, 0.55 W·m2·nm-1 @340 nm, for example) are specified in test standards with very little tolerance for operational fluctuation.

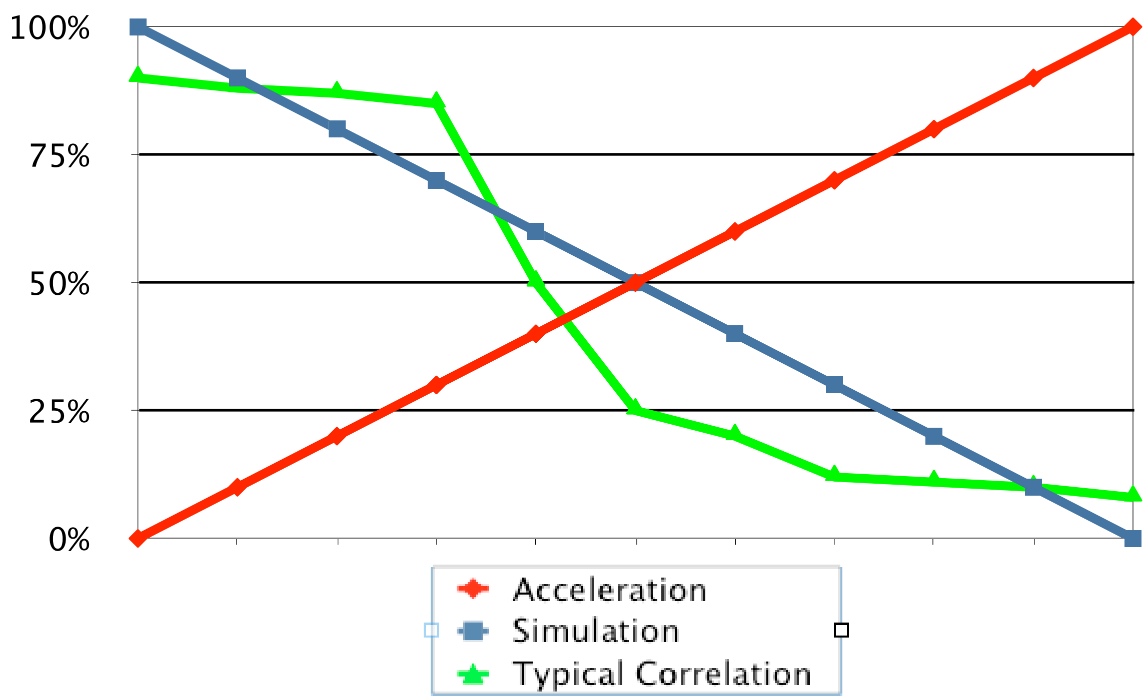


Figure 1. Acceleration, Simulation, and Correlation in Weathering Testing

It has been said of weathering degradation of materials that, "Sunlight initiates, heat accelerates, and water participates." [2] The focus on controlling light spectra in testing is a consequence of the fact that photo-oxidation reactions are initiated by irradiance of material surfaces. Without this initial action, the other forces of weathering will not produce the variety of weathering effects that are observed outdoors, such as color change, gloss loss, strength decrease, and more. Temperature is also an important parameter for weathering testing of materials as it serves to accelerate reactions initiated by light and contributes to secondary photochemical reactions. Thermal cycling also contributes to material fatigue. Thus, precise control of temperature, or heat, is also typically required in laboratory weathering tests. Nearly every major test standard calls for precise control of temperature during each step of the test cycle, controlled by a black panel thermometer (BPT) and/or measurement of chamber air temperature. The approach taken is typically to accelerate weathering testing by increasing specimen temperature, but not by using temperatures so high that materials experience unnatural melting or other specimen degradation modes that are not observed in natural outdoor environments. A range of test temperatures are called for in weathering tests, often varying within tests to reproduce thermal cycling.

Water, the third force of weathering, has often been neglected during the development of laboratory test protocols. As described above, both light and heat are defined and controlled precisely in most weathering test standards. Water delivery, however, is almost never quantified, and in some accelerated weathering tests is not considered at all. One can contrast a typical water specification in a test standard to the light and heat requirements in, for example, the "102/18" cycle prevalent in test standards like ISO 48922 Plastics - Methods of exposure to laboratory light sources – Part 2: Xenonarc lamps. [3] The irradiance in the test is defined via a table of relative spectral irradiance over the range from 290400 nm, a within-chamber uniformity requirement, and a narrowband irradiance of 0.51 ± 0.02 W·m2·nm-1 @340 nm. Test temperatures are specified as Black Standard temperature (BST) of 65 ± 3 °C and a chamber air temperature of 38 ± 3 °C throughout the test. The delivery of water spray, however, is not quantified, other than a requirement to use relatively pure water. No mention is made of spray volume or pressure, or specimen time of wetness. Water spray is conducted while the lamps are still shining, meaning that specimens are likely to dry very quickly. The short 18 minute spray cycles prescribed in this very popular test are insufficient to reproduce the wetness most materials experience outdoors.

This focus on light and heat and neglect of water does a disservice to the field of accelerated laboratory weathering testing. Specimens outdoors are wet for much of the time – 12-16 hours in many locations – and the lack of sufficient water delivery means that the failures generated by aqueous environments are unlikely to be reproduced faithfully in accelerated tests. Water contributes to a range of failure modes, including chalking, blistering, swelling, and delamination. Even for photo-oxidation processes driven by the other forces of weathering, the presence of water can serve to accelerate degradation via mass transport of reaction products.

It is understandable that acceleration of water delivery has been less of an emphasis than acceleration of light and heat. The latter are relatively easy to accomplish, at least in principle: irradiance can be increased by delivering more power to lamps, temperature can be increased by increasing power to the heaters. Accelerating water is a trickier business, however. How can one "speed up" the process of dew, or rainwater, resting on the surface of a specimen? The warm (50-60 °C) condensation steps in UV fluorescent testing offer one solution, but acceleration of water effects remains a challenge, especially in xenon arc testing. Additionally, the historical focus on light intensity was critical because coatings typically had low resistance to UV light. Now that coatings and other durable materials have been reformulated – with guidance from accelerated testing that focused on UV light - these materials have become very durable to photo-degradation. Water delivery in testing is therefore now more relevant. Fortunately, some strides have been made recently in the delivery of water to specimens during laboratory testing of weathering behavior. The next sections will detail test standards for three different types of accelerated weathering testing: natural sunlight concentrator testing (ASTM G90), fluorescent UV testing (EN 927-6), and xenon arc weathering (ASTM D7869). The latter is perhaps the most extensively-researched weathering test protocol, the result of years of study into outdoor weather phenomena, including water as humidity, dew, and rainfall. Following that review, some recent results will be presented that illustrate an example of the impact water delivery can have on accelerated weathering testing.

Accelerated Outdoor Testing: ASTM G90 and D1414

ASTM G90, Standard Practice for Performing Accelerated Outdoor Weathering of Nonmetallic Materials Using Concentrated Natural Sunlight, [4] is a benchmark test protocol for accelerated outdoor weathering tests. These tests employ Fresnel-reflecting solar concentrator accelerated weathering apparatuses (**see Fig. 2**) to expose test specimens to a much higher level of natural sunlight than they would experience during a natural outdoor exposure. Specimens tested in Arizona can receive five times the amount of UV light that they would receive during the same period of time in a natural exposure, without using an artificial sunlight source. This test thus balances acceleration with simulation.

The primary goal of this test is the delivery of high-intensity sunlight and heat to specimens, but this standard also includes a well-designed provision to deliver water spray to specimens, as shown in Table 1 below. Test Cycle 1 includes short water spray cycles during both the day and the night. The day cycles will only produce thermal shock of the specimens and will not lead to material degradation from absorption of water, since water will evaporate quickly in the outdoor heat. The few short nighttime spray cycles are also insufficient to simulate real world time-of-wetness. The spray called for in Test Cycle 3, however, is much more realistic and for durable materials should help generate the kinds of water-based failures that are observed outdoors. The frequent spray cycles - four per hour over the course of 10 hours – have been shown to produce specimen time of wetness similar to that observed in Florida.

Figure 2. Fresnel-reflecting solar concentrator accelerated weathering apparatus

Daytime				Nighttime		
Test Cycle	Spray duration	Dry duration	Cycles	Spray duration	Dry duration	Cycles
1	8 min	52 min	1 / hr	8 min		3 per night: 21:00, 00:00, 03:00
3	none			3 min	12 min	4 per hour (40 total) 19:00-05-00

A related standard, ASTM D4141, Standard Practice for Conducting Black Box and Solar Concentrating Exposures of Coatings, [5] references Test Cycle 3 from ASTM G90, underscoring the usefulness of this accelerated outdoor test for durable materials. This includes materials such as coatings that absorb significant amounts of water.

Accelerated UV fluorescent testing: EN 927-6

Laboratory weathering test methods for UV fluorescent devices typically rely on warm condensation as their primary mode of water delivery. Condensation is the most realistic form of moisture in testing, since it simulates dew, the primary source of outdoor wetness. Additionally, condensation steps can be performed at elevated temperatures to accelerate moisture uptake, while the spray water used in xenon arc testing is at room temperature.

Test protocol EN 927-6, Paints and varnishes - Coating materials and coating systems for exterior wood – Part 6: Exposure of wood coatings to artificial weathering using fluorescent lamps and water, [6] takes great care in delivery of water to specimens, as reflected by the explicit appearance of "water" in the standard's title. Spray cycles in fluorescent UV testing are typically short (15 mins) and infrequent (2× per day), as in ASTM G154, Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials. [7] Condensation steps generally have a duration of 4 hours and alternate with 4- or 8-hour UV light steps. EN 927-6 extends these durations significantly, especially the water spray step. Each one-week cycle of EN 927-6 features one long 24-hour condensation step, followed by 48 threehour subcycles of 0.5 hr water spray and 2.5 hr UV light. This is significantly more water delivery than is called for in other UV fluorescent test standards, and reflects a test designed specifically for one class of materials: coatings on wood [8]. Since coatings and wood substrates can absorb a lot of water and are sensitive to the effects of erosion, both of which can lead to material failure, the deliberate inclusion of a long condensation step and frequent 30-minute spray steps is highly appropriate. The approach actually mirrors that taken in the next example, ASTM D7869.

Accelerated xenon testing: ASTM D7869

ASTM D7869, Standard Practice for Xenon arc Exposure Test with Enhanced Light and Water Exposure for Transportation Coatings, [9] is the most thoroughly-researched weathering standard in history [1, 10]. Years of collecting data on outdoor weather in South Florida, hundreds of long-term natural reference material exposures, and repeated experiments to develop an accelerated test cycle resulted in a test that accurately reproduces all critical failure modes observed outdoors for a wide range of automotive and aerospace coatings. Great care was taken in defining the light spectrum seen by specimens, resulting in development of a new optical filter. Test temperatures were selected that accelerate material degradation without producing unrealistic failures not seen in outdoor exposures.

Perhaps the most significant breakthrough in ASTM D7869 was in characterizing water delivery [11, 12]. Weather data demonstrated that materials in South Florida, a benchmark location for sub-tropical outdoor testing, are wet for 12-16 hours a day, primarily from condensation. This underscored the inadequacy of existing xenon arc tests for reproducing water effects. It was clear that water-based failures of coatings, like delamination and blistering, could not be reproduced accurately with existing test protocols. The schematic diagram in Figure 3 illustrates the key features of this cycle with respect to water delivery. Each 24-hour cycle contains two long water steps – a 4hour step and a 2.5-hour step, meant to reproduce long overnight periods of wetness. The 40 °C temperature setpoint for the 4-hour step was shown to fully saturate coatings with water in the same manner as outdoor exposures, making this an effective method of accelerating water delivery.

No water spray takes place during the light portion of the ASTM D7869 test cycle. This is logical since both condensation and rainfall outdoors generally take place in the absence of sunshine. Tests like the 102/18 cycle mentioned earlier employ water spray during light steps, which can not only generate unrealistic levels of thermal shock and produce cracking, but will quickly dry out and not reach proper saturation. The second half of the ASTM D7869 test does include a number of shorter water spray steps intended to simulate rain events. These steps thermally stress materials without generating failures that are not observed outdoors.

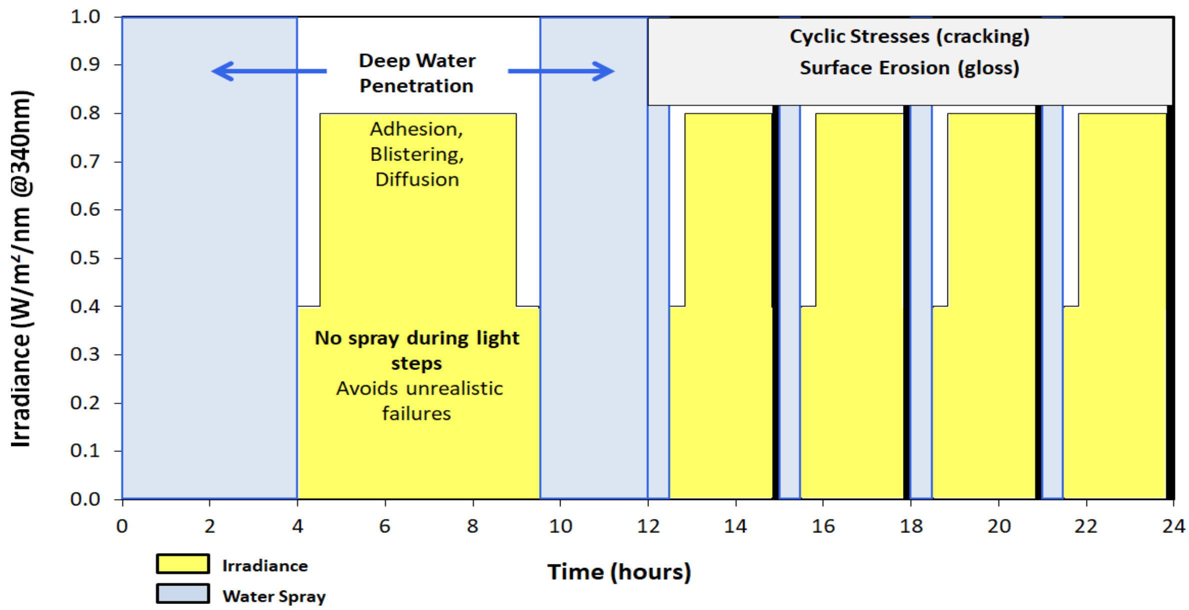


Figure 3. Schematic diagram of ASTM D7869 test cycle

ASTM D7869 also took the unique step of quantifying water delivery in accelerated laboratory weathering testing, by means of a calibrated sponge. Prior to performing testing, a spray cycle is performed for 5 minutes with the sponge installed in the tester. If the sponge has absorbed a minimum of 10 g of water after that period, the apparatus is qualified to perform the test. If the sponge has absorbed less than that amount, then the water delivery must be increased for the machine to be qualified. No maximum is set, as the goal is specimen saturation.

This qualification procedure represents a critical advancement in weathering testing. As described earlier, irradiance and temperature are nearly always specified precisely in laboratory test methods while water spray is rarely quantified or incorporated to a sufficient extent. ASTM D7869 addresses those deficiencies, resulting in a test method that accurately reproduces color change and gloss loss, as do other tests, but also water-dependent degradation paths like delamination, swelling, blistering, and chalking. The test results from painted metal panels in Figure 4 demonstrate how ASTM D7869 reproduces multiple failure modes as compared to SAE J2527. The latter is a widely-used test standard that simulates well color change and gloss loss observed outdoors but misses some water-based coatings failures. Both laboratory tests shown in Fig. 4 (center and right panels) generate the color change and delamination observed during outdoor Florida exposures (left panel) in a fraction of the test time. However, only the ASTM D7869 test also generates the coating blistering characteristic of water high levels of water absorption. Testing during development of ASTM D7869 consistently demonstrated that this test protocol effectively reproduced a wide range of degradation modes for transportation coatings.

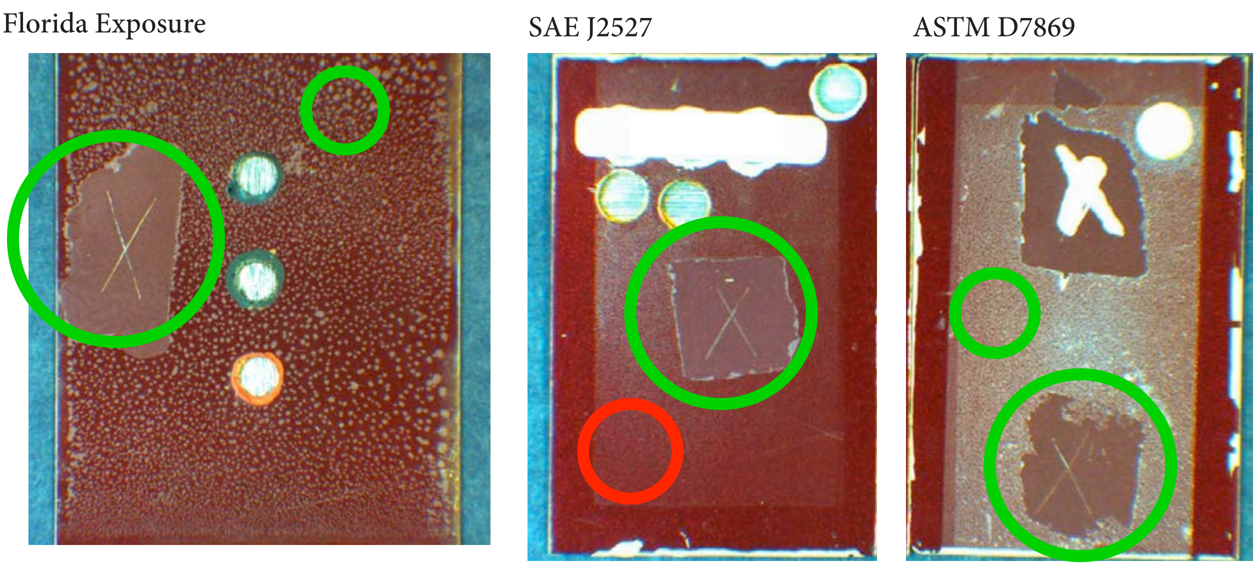


Figure 4. Test results from coated metal panels after testing outdoors in Florida (left panel) and in accelerated laboratory testing with SAE 2527 (center) and ASTM D7869 (right).

The test results in the next section isolate the effects of water on testing of some other materials testing and show its significance on polymer degradation.

Water in accelerated testing of plastics

The accelerated test protocols described in the preceding sections highlight the fact that water can have a significant effect on a number of different material degradation modes. This section presents some test results indicating that the impact of water on testing is not always consistent from material to material. One example is given in Figure 5, illustrating gloss retention in urethane specimens tested with and without water condensation [13]. The upper dotted line in the figure for testing without water delivery shows almost zero change in the materials' glossiness. The lower dashed line, which includes condensation steps, shows a sharp decrease in material glossiness. These tests show how markedly different weathering behavior can be for materials tested with and without proper water delivery, and that these phenomena can affect bulk polymers, not just coatings.

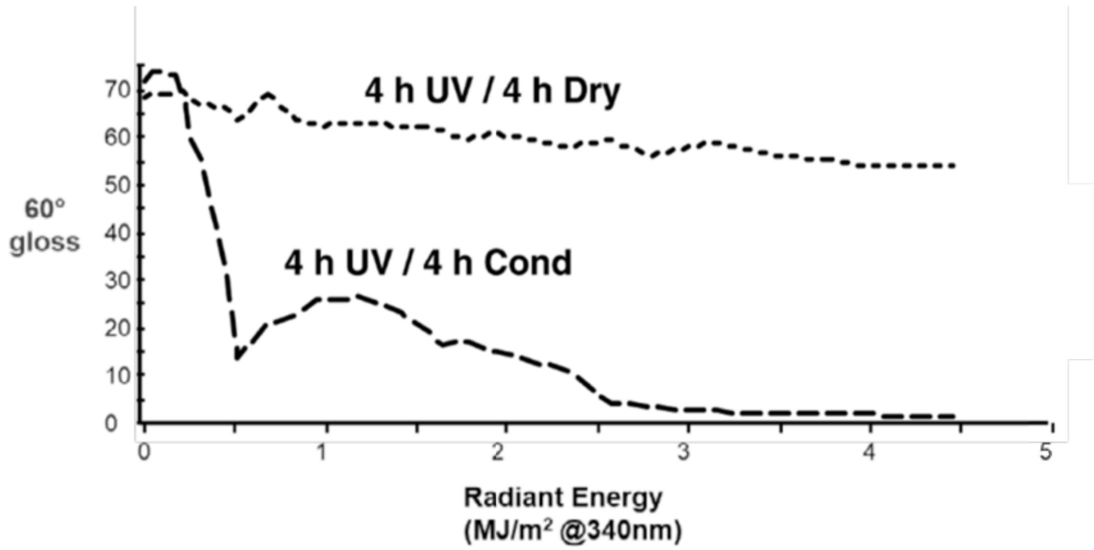


Figure 5. Gloss retention for urethane after UV fluorescent testing with no water condensation (dotted line) and with condensation (dashed line)

The graph in Figure 6 shows delta E (total color change) results obtained for black polypropylene (PP) specimens using a modified version of the "102/18" style ISO 4892-2 test protocol. Tests were conducted with three levels of water delivery – the standard volume of spray for the xenon arc tester, a reduced amount of water, and a higher-than-usual level of water spray, similar to that used for ASTM D7869. The test performed with the normal amount of water spray shows very little change through 600 hours of testing, after which a significant increase in color change can be observed. However, for tests conducted with reduced and no water spray, color change remains minimal for much longer. The test with reduced water spray does begin to show additional color change after 1200 hours or so of testing. These results are not surprising, since water can contribute to weathering degradation from color change in several ways. The additional water may serve to better wash reaction products away from specimen surfaces, exposing fresh surfaces for photo-oxidation to take place. The presence of water can also facilitate chemical reactions in solution and accelerate color change. Additionally, for some specimens, long periods of water might generate cracking, swelling, and other defects, but that was not observed in this work, perhaps owing to the choice of test protocol.

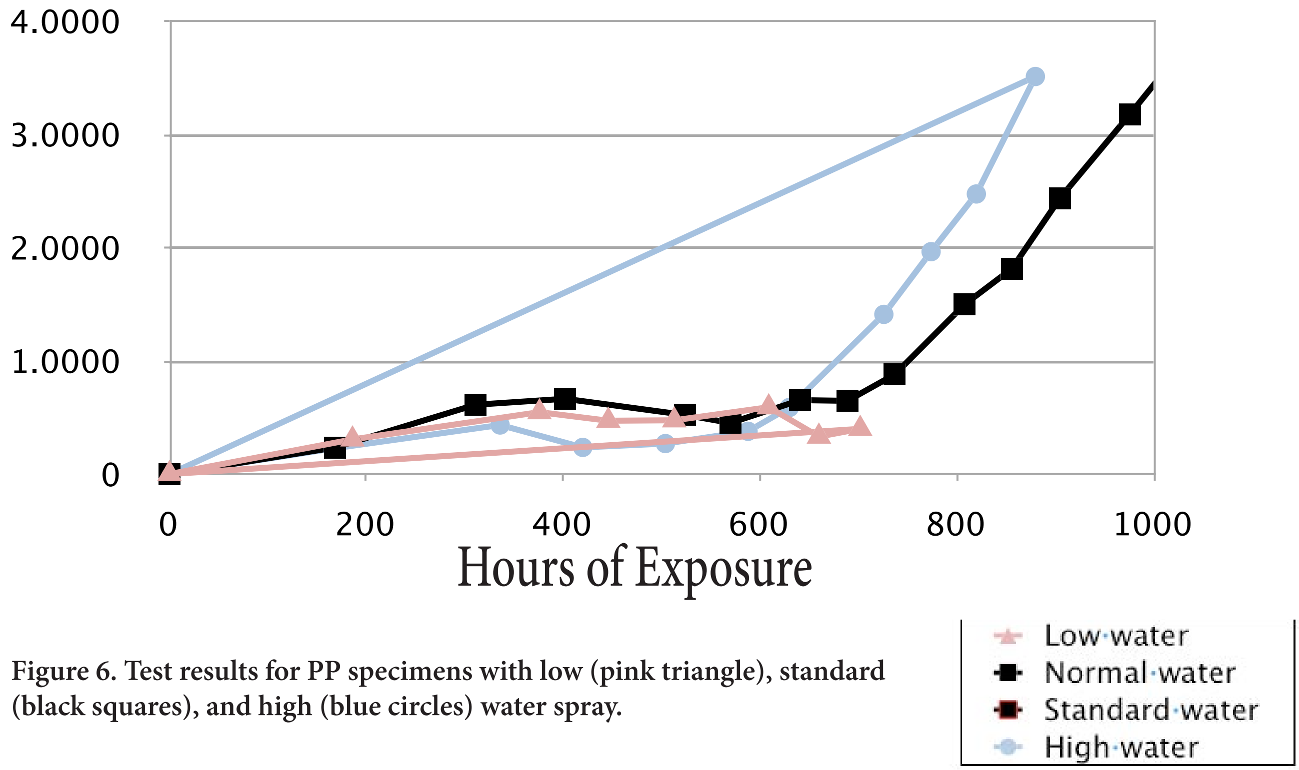


Figure 6. Test results for PP specimens with low (pink triangle), standard (black squares), and high (blue circles) water spray.

The graph in Figure 6 shows delta E (total color change) results obtained for black polypropylene (PP) specimens using a modified version of the "102/18" style ISO 4892-2 test protocol. Tests were conducted with three levels of water delivery – the standard volume of spray for the xenon arc tester, a reduced amount of water, and a higher-than-usual level of water spray, similar to that used for ASTM D7869. The test performed with the normal amount of water spray shows very little change through 600 hours of testing, after which a significant increase in color change can be observed. However, for tests conducted with reduced and no water spray, color change remains minimal for much longer. The test with reduced water spray does begin to show additional color change after 1200 hours or so of testing. These results are not surprising, since water can contribute to weathering degradation from color change in several ways. The additional water may serve to better wash reaction products away from specimen surfaces, exposing fresh surfaces for photo-oxidation to take place. The presence of water can also facilitate chemical reactions in solution and accelerate color change. Additionally, for some specimens, long periods of water might generate cracking, swelling, and other defects, but that was not observed in this work, perhaps owing to the choice of test protocol.

Weathering behavior is not generally consistent from material to material, which is why it is critical to test materials outdoors to determine a benchmark for correlation in addition to performing accelerated tests. Minor changes in specimen formulation can cause significant differences in weathering behavior. Generalized acceleration factors and rules about the influence of the different forces of weathering typically cannot be established and testing needs to be performed. High irradiance, for example, is typically thought to accelerate weathering degradation, and in many cases it does. This is true, for example, for polyvinyl chloride (PVC) films, where higher irradiance greatly accelerates yellowing. Acrylonitrile butadiene styrene (ABS) sheets, on the other hand, show only a modest increase in aging with greater irradiance. Polypropylene (PP) sheets in some accelerated testing will show no acceleration in yellowing at higher irradiance levels, although within polypropylene materials this can vary depending on formulation. Variation in material response exists for temperature as well – although higher test temperatures lead to more rapid strength loss for polyethylene (PE) specimens, some polyketone thermoplastics show basically the same behavior regardless of test temperature.

This variability in response to test conditions can be observed for water delivery as well. Although the work in ASTM D7869 demonstrated that water delivery in testing was critical to generate particular failure modes, that does not necessarily mean that increased water always accelerates degradation as in the previous examples. Different specimens of polypropylene (PP) were tested using the modified ISO 4892-2 test protocol with varying levels of water delivery, as shown in Figure 7. Here, five levels of water delivery – the apparatus standard spray plus two lower levels and two higher levels – show a clear trend in delta E (total color change) of these black specimens. In this case, an increase in water delivery consistently decreases the extent of color change, meaning that the low-water tests are harsher for this particular material and failure mode. This reinforces the concept that different material formulations can exhibit very different responses to the forces of weathering.

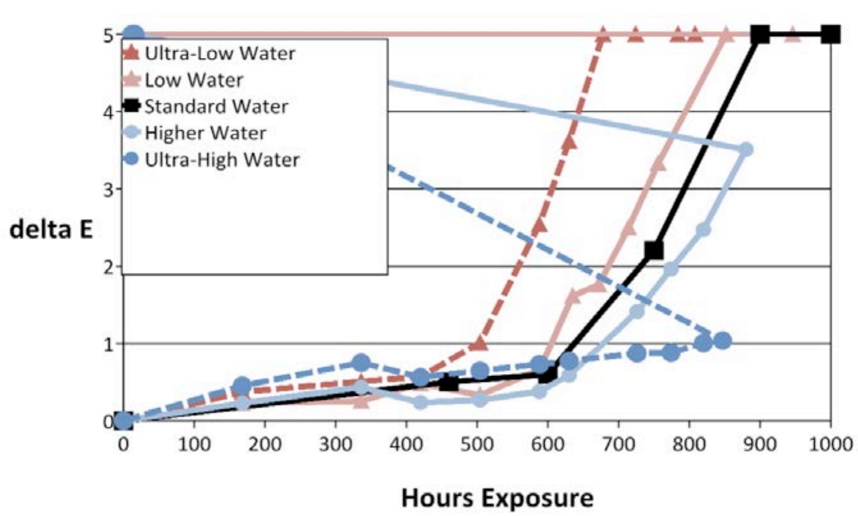


Figure 7. Test results for PP specimens with very low (dashed line, red triangles), low (solid line, pink triangles), standard (black squares), high (solid line, blue circles), and very high (dashed line, blue circles) levels of water spray.

Summary and Conclusions

Accelerated weathering testing has traditionally focused on quantifying and delivering accelerated levels of light and heat to test specimens. This means that tests have often failed to reproduce the effects that are observed in natural outdoor weathering, particularly in regions with high time-of-wetness. However, accelerated weathering test standards for natural sunlight concentrator testing (ASTM G90), UV fluorescent testing (EN 927-6), and xenon arc weathering (ASTM D7869) have taken steps to improve the delivery of water to specimens to better reproduce critical degradation phenomena.

For the case of transportation coatings tested using ASTM D7869, the addition of long-duration water steps reproduces outdoor phenomena not available to other accelerated testing. The examples of urethane and polypropylene testing illustrate that the effect of water is not always straightforward. In particular, some specimens of polypropylene experienced more degradation as a result of higher water levels during testing, while others showed the reverse effect. This demonstrates the fact that changes in material formulation can have significant effects on material weathering performance and that new and changed specimen formulations should always be tested.

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COLOR & APPEARANCE

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2021 to 2024 Term

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SPE CAD Board of Directors

The election is open to current SPE members with CAD as their primary division. Time commitment would be for four meetings per year for 3 year terms. Two of the meetings will correspond with ANTEC® and RETEC® where you will participate in CAD activities and initiatives. Members of the Board participate in the planning, organization and running of CAD activities including ANTEC® programs, RETEC® programs, Technical Programs, Scholarship Programs & Funding, as well as offering guidance and advice to other SPE members interested in coloring plastic resins.

SPE Council Representative (CAD)

The Color & Appearance Division of the SPE is also electing a Council Representative for the 2021 to 2024 term. The CAD Councilor provides the CAD members a voice in the government of SPE by representing the SPE Color & Appearance Division at SPE Council meetings (3-4 meetings per year – 2 meetings at ANTEC®, 1 face-to-face meeting in the Fall and potentially one conference call).

To be listed as a candidate or have questions about becoming a candidate, please Email or call Chair Elect Mark Tyler. Please Email a picture of yourself, educational background, employment (current and prior), and why you wish to be a candidate to:
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All candidates must be identified and have all their information to SPE CAD BOD by **March 19th, 2021**

Visit SPECAD Website for more information

SPE COLOR & APPEARANCE DIVISION MISSION STATEMENT:

The Color and Appearance Division of SPE strives to educate, train, inform, and provide professional interaction opportunities to the global community involved in visual performance and aesthetics of plastics.

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The Color and Appearance Division regularly holds Board of Director (BOD) meetings at the ANTEC® and the CAD RETEC®. In addition, a Summer BOD meeting is typically held about 6 weeks prior to the next CAD RETEC® .

The Summer meeting is scheduled in various locations. A Winter BOD meeting is held in January. The Winter meeting is typically held at a site of a future CAD RETEC®.

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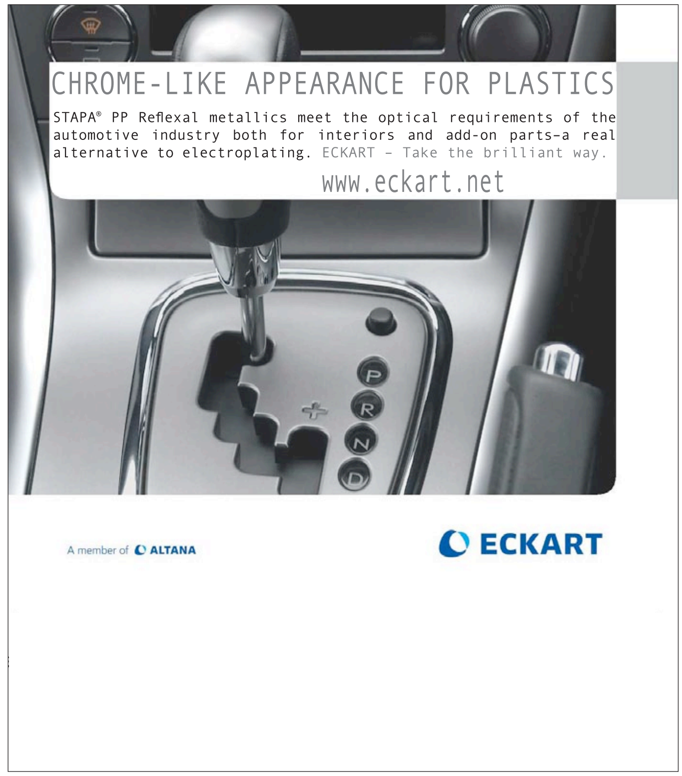

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