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Drawing on decades of weathering leadership and expertise, the Atlas Consulting Group provides in-depth consulting services that assist you in developing and applying the best weathering test methods and strategies for your products. ***Atlas Weathering Consulting Insights*** offers interesting and valuable information on a variety of topics relevant to long-term durability testing.

Can't Find a Standard That Fits? Maybe You Could Use a Good Custom Tailor

This issue of the Atlas Weathering Consulting Insights Newsletter is the fourth installment of a six-part series on various aspects of weathering test tailoring - that is, adapting or creating weathering tests as appropriate for specific circumstances. The first installment covered special mechanical stresses.

Weathering Test Tailoring Part 4: Multiple Environment Stress Combinations

An important aspect in weathering testing is the concept of "test tailoring." In other words, the overall approach must be appropriate for the product and the testing objective. This is particularly true when trying to relate laboratory weathering test performance to that in a specific service environment. In most cases, standard weathering test methods are not designed, nor do they claim, to represent or predict performance in any specific climate, such as the common South Florida benchmark. In many weatherability projects, it is necessary to modify existing test methods, or design new ones, to better simulate a target climate while still providing a reasonable level of overstress test acceleration to be useful.

The selection of the key stress conditions for the primary weather factors of "heat, light and moisture" is important, as synergistic "interaction effects" can occur in specific materials where two or more stresses interact to produce degradation greater than the sum of that caused by the individual stresses. These can be represented in a classic "two cubed" (i.e., 2^3) design of experiment (DoE or DoX) where each of the three stresses are shown (and sometimes tested) with each variable at both a low and high value. This produces eight (2^3) unique test conditions (black dots in Figure 1), a much more efficient and reliable methodology than changing only one factor at a time (OFAT). The property of interest is measured at each of the test conditions indicated by the dots; in a "full factorial" design, both the effects of the individual stresses as well as the combination of various stress interactions can be determined.

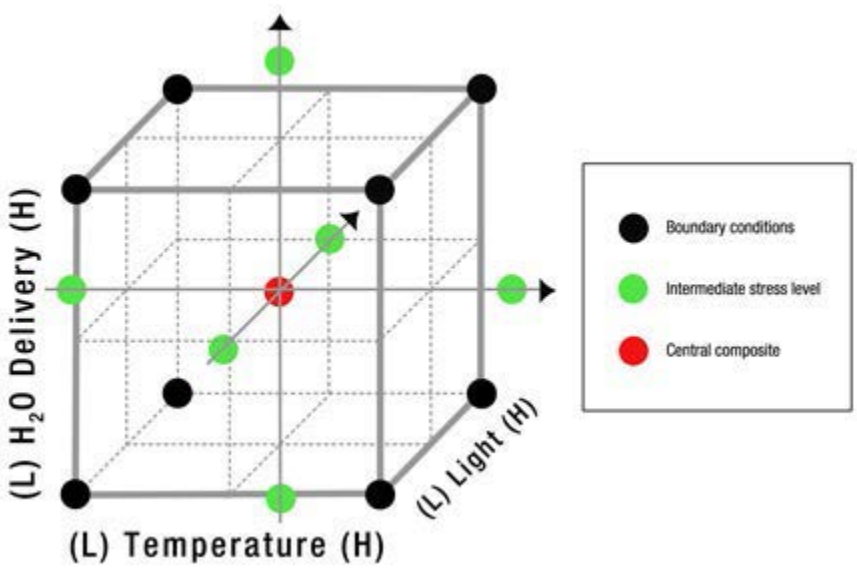
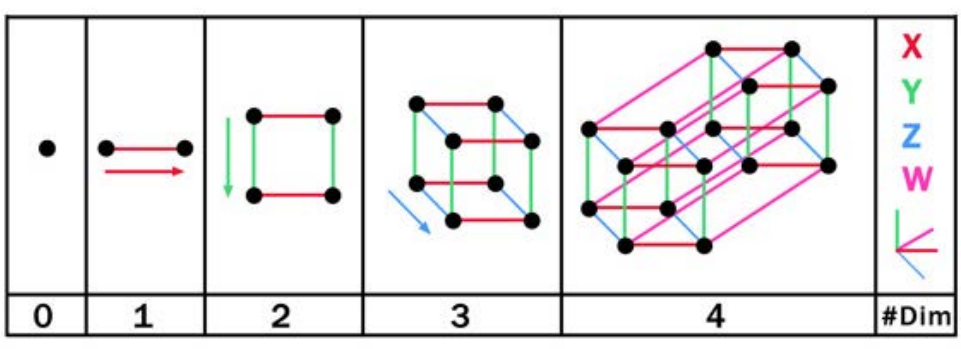


Figure 1. 2^3 design



n = 1 to 4 stresses with each at 2 levels (2^n) designs

Figure 2. 2^n design

This basic concept can then be expanded, if necessary, to include multi-step stress levels (shown by green dots), or cyclic, rather than steady state conditions. They may also include additional environmental stress variables beyond the basic "heat, light, moisture" for a "hypercube" test design (1-4 variables shown in Figure 2). In a Weather-Ometer® the fourth variable can be water spray time (as opposed to RH%), chamber temperature (CHT), UV cut-on wavelength, radiant energy, etc.

An example of using this concept to develop a test cycle is that of ASTM D7869-13, *Standard Practice for Xenon Arc Exposure Test with Enhanced Light and Water Exposure for Transportation Coatings*, designed to specifically reproduce South Florida weathering for automotive and aerospace exterior coatings. This test cycle uses coating water content as one of the design variables. It is also the first standard cycle to use a three-level irradiance step profile (off, mid and high level), as well as a multi-level temperature profile to more closely mimic the natural "heat, light and moisture" diurnal cycle of South Florida.

Lastly, it is sometimes not practical or possible to include all of the necessary parameters into a single test cycle or instrument. For example, freeze-thaw cycles or salt corrosion may be important stress factors that can't be incorporated into a standard accelerated weathering test. In these cases it may be necessary to alternately sequence incompatible tests. One example of this is ASTM D5722-08, *Standard Practice for Performing Accelerated Outdoor Weathering of Factory-Coated Embossed Hardboard Using Concentrated Natural Sunlight and a Soak-Freeze-Thaw Procedure*, which alternates an EMMAQUA® concentrated sunlight exposure with a nightly laboratory water soak-freeze-thaw cycle. Another is ASTM D5894 – 10, *Standard Practice for Cyclic Salt Fog/UV Exposure of Painted Metal, (Alternating Exposures in a Fog/Dry Cabinet and a UV/Condensation Cabinet)*, which is equivalent to ISO 11997-2:2013 which alternates a corrosive salt fog (a.k.a. salt spray) test with a laboratory xenon-arc or UV exposure (e.g., UVTest). Atlas has also used alternating xenon arc weathering with temperature cycling in environmental chambers, to simulate photodegradation and thermomechanical degradation in one procedure.

As materials and products chemically and physically age from weather exposure, they often become more "sensitive" to weathering stresses. Therefore, it is often necessary to devise test programs consisting of various sub-cycles to reproduce this aging characteristic. Perhaps the most complex weathering cycle developed for multi-climate weathering simulation to date is the comprehensive Atlas 25+® program for the long-term durability testing of photovoltaic modules (solar panels), variations of which are now being used for other products designed for long-term outdoor use.

Oftentimes, real world products face unique conditions which mandate custom-tailored test programs as there may be no specific product or test standards by which to refer. If you should have such a product, contact the Atlas Consulting Group at **atlas.info@ametek.com**(US) or **atlas.info@ametek.de** (Europe) to help you. The Atlas Consulting Group specializes in test tailoring, designing and implementing testing programs for clients to yield meaningful and useful results on a cost effective basis.

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