“When you can measure what you are speaking about, and express it in numbers, you know something about it.

When you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind.

It may be the beginning of knowledge, but you have scarcely, in your thoughts advanced to the stage of science.”

William Thomson, 1st Baron Kelvin
Inventor of the Absolute (Kelvin) Temperature Scale

“In God we trust;
all others must bring data.”

W. Edwards Deming

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The goal of weathering is to
Predict the Future

How long will this product last?

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The goal of weathering is to ***Predict the Future*** *using*

What is the probability/technical risk of in-service failure as a function of time and end-use environment?

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Applying Weathering Science to Predict the Future – The Reliable Approach to Estimating Product Service Life

David M. Burns
Weathering Research Center
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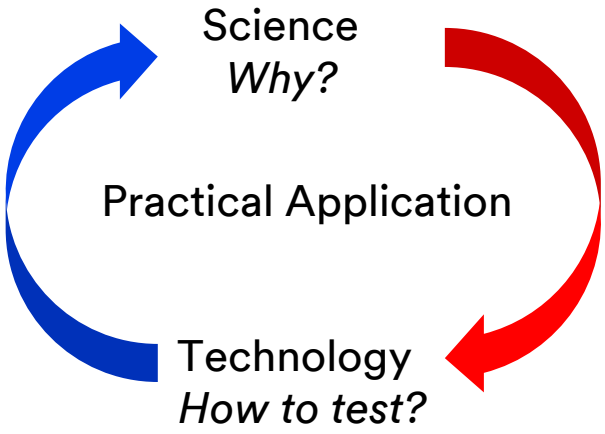
St. Paul MN USA

Weathering Science

Weathering Science (*polymer systems*) - The multi-disciplinary field focused on understanding the sources, processes and pathways resulting in degradation of the functional properties of materials & systems in outdoor applications.

Photochemistry **Polymer Chemistry** **Materials Engineering**
Reaction Kinetics **Analytical Sciences** **Metrology**
Data Analytics & Statistics **Climatology**

Weathering Technology - The tools (equipment and protocols) for conducting systematic experiments in weathering science.



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The Science of Weathering

Weathering (*polymeric systems*) – changes in material properties resulting predominantly from exposure to solar radiation in combination with heat and water, in its various states.

Discussion— Solar radiation, heat and water are the primary stress factors in the natural environment. Secondary stress factors specific to a climate or location include temperature cycling, wind born particulates and chemicals in the atmosphere.

Sunlight → **Heat** + **Water** → **Degradation**

$P + h\nu \rightarrow P^*$

$dP/dt = Ae^{-Ea/RT}$

$dP/dt = k[H_2O]^n$

$S_P = [H_2O]/[P]$

$\Pi_P = iM_{H2O}RT$

*Weathering **is** the response to stress;*
*Weathering is **not** the stress applied.*

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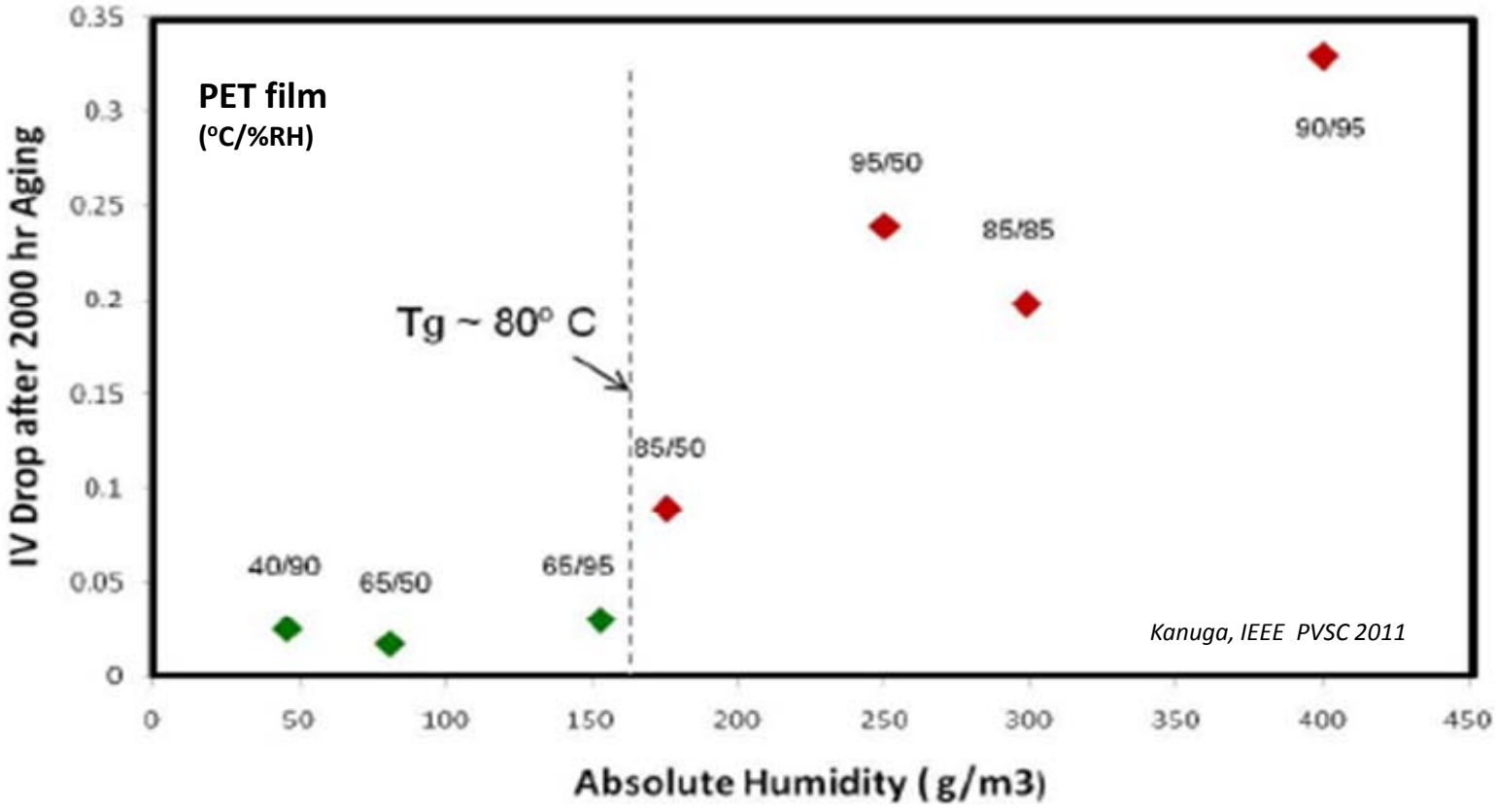
NOTE! Light is NOT always a factor in degradation

~~Sunlight~~ → **Heat** + **Water** → **Degradation**



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Weathering Science focuses on quantifying the material's response to stress rather than just relating property changes to exposure duration.

"…The *new concept of exposure parameters …to describe the mode of dependence of properties … on exposure variables*, and to simplify the mathematical treatment of the data…can be used for the prediction of outdoor weathering characteristics of a variety of plastic materials with surprisingly good agreement…such a shift in objective would *require basic changes in methodology and analytical procedures*…"

Musa R. Kamal ***(1966)*** *Polymer Engineering & Science, v.6 (4) 333-340*

$$P(t)-P(0) = \int_0^{t_F} (A\, \boldsymbol{I}^{n} * \beta\, e^{-Ea/R\boldsymbol{T_s}} * \gamma [\boldsymbol{RH}]^{m})\, dt$$

Quantitative Degradation Modeling is the key to Reliable Service Life Prediction

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1966

Musa R. Kamal,* *Stamford Research Laboratories, American Cyanamid Company, Stamford, Connecticut*

Effect of Variables in Artificial Weathering on the Degradation of Selected Plastics

POLYMER ENGINEERING AND SCIENCE, OCTOBER, 1966

1996

REFERENCE: Kim, H. M.• Jorgensen, G. J., King, D. E., and Czanderna, A. W., "Development of a Methodology for Service Lifetime Prediction of Renewable Energy Devices," Durability Testing of Nonmetallic Materials. ASTM STP 1294, Robert J. Herling, Ed., American Society for Testing and Materials, 1996.

2004

CONSIDERATIONS FOR RELATING ARTIFICIAL LABORATORY AND NATURAL OUTDOOR WEATHERING DURABILITY TESTING

Henry K. Hardcastle III, Atlas Material Testing Technology LLC

ANTEC 2004 / 4077

2014

Service Life Prediction of Exterior Plastics pp 21-40 | Cite as

Laboratory-Based Predictions of Weathering in Outdoor Environments over the Entire Degradation Pathway

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Conference paper
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1 Citations 1 Readers 361 Downloads

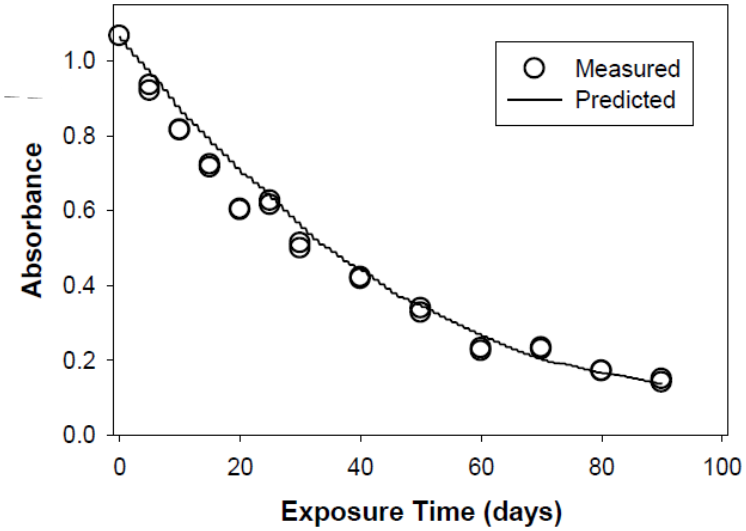

Figure 7. Degradation of peak absorbance in the film specimens predicted by the SLP model for the outdoor exposure near New River, Arizona from July 23 to Oct 21, 2008. The prediction was based on climate data measured at the site during the exposure. The degradation observed experimentally is shown for comparison.

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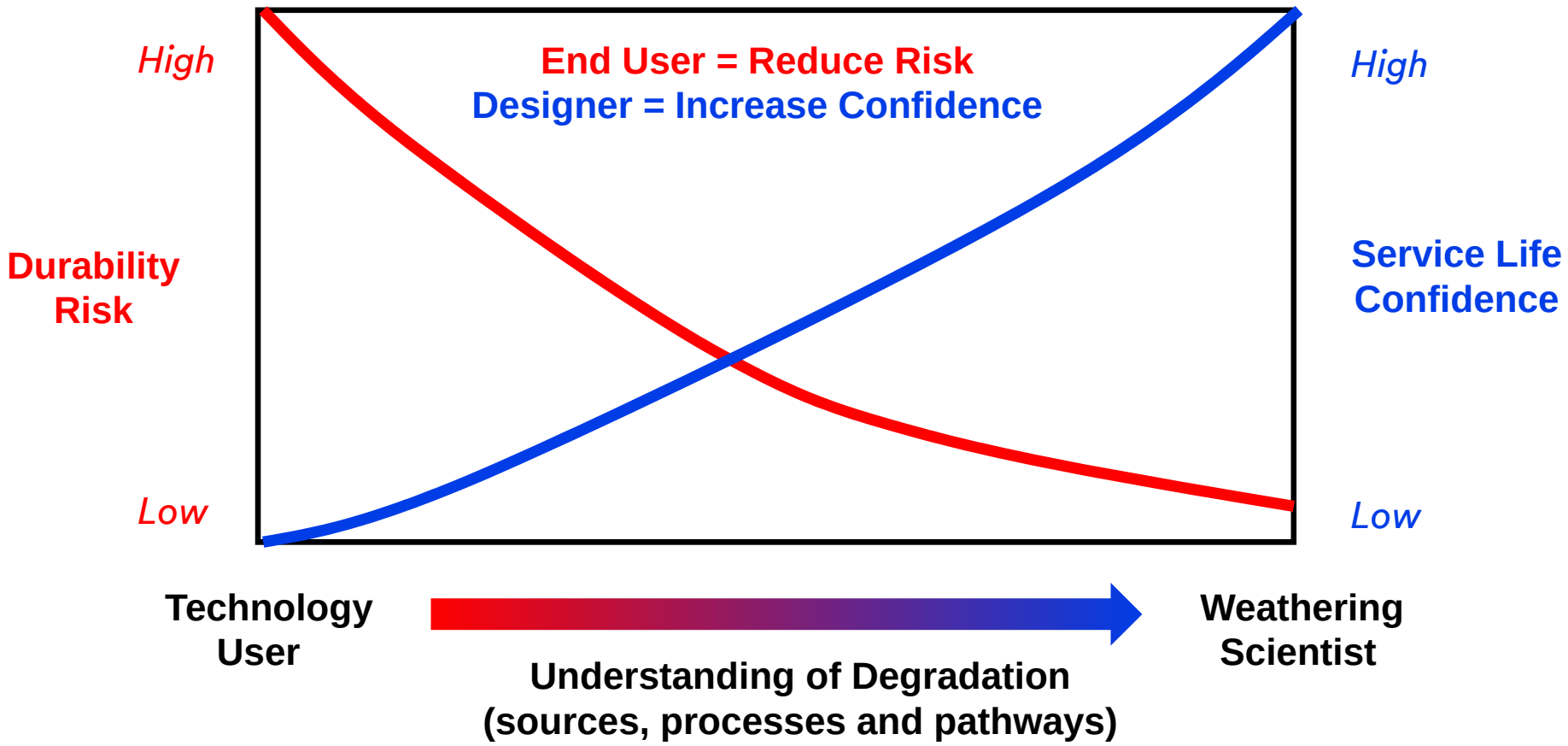
How long will this product last?



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Thank you

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