JMP Instructional data set 014

# Paint Wear Accelerated Testing

STATISTICAL DISCOVERY

## JMP platforms and statistical methods

**Graph Builder:** Scatterplot
**Fit Y by X:** Simple linear regression
**Formula Editor:** Creating new variables

## Problem statement

Manufacturers of paint and other coating materials are very interested in having reliable estimates of the material's durability against undesired effects such as fading of color (Figure 1a.), cracking/peeling (1b.), and blistering (1c.), among others

Figure 1a.

Figure 1b.

Figure 1c.

R&D teams for these types of manufacturers are constantly conducting tests to describe and quantify a material's durability. One type of testing subjects the paint to different real natural environments. For example, the hot humid weather of Florida (Figure 2a.), long hot dry heat of Arizona (2b.), and the cold winters and seasonal temperature fluctuations of Minnesota (2c.).

Figure 2a.

Figure 2b.

Figure 2c.

Since these effects take many years to manifest in these environments, manufacturers need a much quicker way to study the rate of these undesired effects to guide product development. Scientists use environmental chambers that can vary temperature, humidity, and UV levels to simulate the long-term effects caused by real environmental conditions but in a greatly accelerated time frame (Figure 3).


Figure 3.
Image of Accelerated Weathering Tester from Q-Lab®
https://www.q-lab.com

It is necessary to determine the settings for the accelerated testing chamber so that those results match the results that would occur in real natural environmental conditions so that reliable estimates can be produced.

In this study, historic data from many samples over many years of real testing from outdoor fields in Florida, Arizona, and Minnesota was gathered. Characteristics such as amount of fading, cracking, and blistering were quantified through a series of measurements made through instrumentation and visual assessment. Resulting data is a value from 0 to 1 representing the severity of the damage.

Test panels were prepared and placed in the accelerated weathering tester with environmental conditions set to simulate the three locations with the intent of one week in these chambers equating to one year in the field.

The objective of these analyses will be to evaluate how closely the amount and type of damage of paint of an accelerated weathering tester matches how paint performs when it is exposed to various real environmental conditions.

## Data

**IDS_014.jmp**

| | |
|---|---|
| **Condition** | The three real and simulated conditions (Florida, Arizona, Minnesota) |
| **Years** | Years paint samples were in the real outdoor environment and the simulated years in the accelerated tester |
| **Fading_Real** | Amount of fading from outdoor environment (0-1 scale) |
| **Peeling_Real** | Amount of peeling from outdoor environment (0-1 scale) |
| **Blistering_Real** | Amount of blistering from outdoor environment (0-1 scale) |
| **Fading_Lab** | Amount of fading from accelerated weathering tester (0-1 scale) |
| **Peeling_Lab** | Amount of peeling from accelerated weathering tester (0-1 scale) |
| **Blistering_Lab** | Amount of blistering from accelerated weathering tester (0-1 scale) |

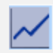
## Exercises

1. Create the following visualizations that can be used to compare the amount of wear between the real environmental conditions to the simulated conditions from the accelerated tester.
   *Note: These visualizations are alternative ways to make the comparisons. You may find one version better than the others at illustrating the similarities and/or differences.*

   a. Create three scatterplots (one for each type of wear) comparing the amount of wear that occurs in the real environmental conditions vs. the accelerated tester.

> ***Instructions:***
> *Graph > Graph Builder. Place 'Fading_Real' on the Y axis, and 'Fading_Lab' on the X. Place 'Condition' in the Color Role.*
>
> *Choose to remove the smoother by deselecting in the graph palette.* 
>
> *Add a line on the graph at y=x that would correspond to perfect agreement between the two variables:*
> *Right-click on the graph. Choose Customize. Click "+". Then select "Y Function" under "Templates". Edit "Y Function(_function_of_x_,x)" to "Function(y=x, x)".*
>
> *Repeat these steps for the other two types of wear.*

b. Create three scatterplots (one for each type of wear) comparing the amount of wear that occurs in the real environmental conditions vs. the accelerated tester across years.

> ***Instructions:***
> *Graph > Graph Builder. Place both 'Fading_Real' and 'Fading_Lab' on the Y axis. Place 'Year' on the X axis.*
>
> *Choose to remove the smoother by deselecting in the graph palette.* 
>
> *Choose to display both the points*  *and line graph,* 
> *by selecting each from the graph palette while holding down the shift key.*
>
> *Select the Local Data Filter under the red triangle. Choose 'Condition' and select the "+" symbol. Now an individual condition can be selected so the graph only shows the data for that condition.*
>
> *Repeat these steps for the other two types of wear.*

c. Create a new set of variables that is the difference between the amount of wear in the real environmental conditions from the amount in the accelerated tester.

> ***Instructions:***
> *Select New Columns under the Cols menu. Name the column "Fading_Diff". Under the Columns Properties drop down menu, select Formula. Then select the Edit Formula button. Create the following formula:*
>
> *Fading_Real* − *Fading_Lab*
>
> *Click OK.*
>
> *Repeat these steps for the other two types of wear.*

d. Create three scatterplots (one for each type of wear) plotting the difference in the amount of wear between the real environmental conditions and the accelerated tester across years.

> ***Instructions:***
> *Graph > Graph Builder. Place ‘Fading_Diff’ on the Y axis and ‘Year’ on the X axis.*
>
> *Choose to remove the smoother by deselecting in the graph palette.* 
>
> *Choose to display both the points*  *and line graph,* 
> *by selecting each from the graph palette while holding down the shift key.*
>
> *Add a reference at 0 by double-clicking on the Y axis to open up the Axis Settings. In the Reference Lines section, type in the value “0” and click “Add”.*
>
> *Select the Local Data Filter under the red triangle. Choose ‘Condition’ and select the “+” symbol. Now an individual condition can be selected so the graph only shows the data for that condition.*
>
> *Repeat these steps for the other two types of wear.*

2. Based upon the graphs you created, describe any difference you see in the amount of agreement between results from the real environmental conditions and the accelerated tester. Is the amount of agreement/disagreement consistent across the 3 types of wear and/or the 3 environmental conditions? If not, describe how it differs. Which type of conditions and wear have the best/worst agreement? Is the amount of agreement/disagreement consistent over the 10 years? If not, describe how the disagreement is different.

3. For each type of wear and environmental condition, fit a linear regression model with the difference variables (created in 1c.) as the Y, Response and Years as the X, Regressor. Provide an explanation of why these linear regression equations could be useful and how they could be used. Illustrate that usage with a few examples.

> ***Instructions:***
> *Analyze > Fit Y by X. Use ‘Fading_Diff’ as the Y. Use ‘Year’ as the X.*
> *Place ‘Condition’ in the By role. Click OK.*
>
> *Under the red triangles next to each Condition, select Fit Line.*
>
> *Repeat these steps for the other two types of wear.*

4. For each of the nine linear regression models, add 95% Confidence Intervals and 95% Prediction Intervals. What do these two intervals represent? Demonstrate how to use and interpret these intervals by illustrating with a few different scenarios (e.g., choose a type of wear, an environmental condition, and a Year).

> ***Instructions:***
> *Analyze > Fit Y by X. Use 'Fading_Diff' as the Y. Use 'Year' as the X.*
> *Place 'Condition' in the By role. Click OK.*
>
> *Under the red triangles next to the titles Linear Fit for each of the nine regression models, select Profiler.*
>
> *Under the red triangles next to the titles Prediction Profiler, select Confidence Intervals, Prediction Intervals, and Data Points.*
>
> *To illustrate interpreting these intervals, drag the red vertical dotted line to select a given year. On the left of the graph, the point estimate, confidence interval, and prediction interval are shown.*

5. What are some reasons why it would not be possible to produce perfect predictions of the amount of wear that would occur in a particular environment regardless of how much testing and data collection is done?

6. What are some ideas for further experimentation the R&D team could take to help them in their efforts to get closer agreement between the results from the testing chambers to what happens in real environmental conditions?