

# stat teaser

## Workshop Schedule

### DOE Simplified

May 29: Minneapolis, MN

An overview of Design of Experiments (DOE) from A to Z, based on the popular book. \$295\*

### Statistics for Technical Professionals

February 19–20: Minneapolis, MN

June 24–25: Minneapolis, MN

Revitalize the statistical skills you need to stay competitive. \$995\*

### Experiment Design Made Easy

January 7–9: Minneapolis, MN

March 4–6: Minneapolis, MN

April 1–3: Philadelphia, PA

May 6–8: Seattle, WA

June 10–12: Minneapolis, MN

Study the practical aspects of DOE. Learn about simple, but powerful, two-level factorial designs. \$1495\*

### Response Surface Methods for Process Optimization

March 18–20: Minneapolis, MN

Maximize profitability by discovering optimal process settings. \$1495\*

### Mixture Design for Optimal Formulations

February 4–6: Philadelphia, PA

May 13–15: Minneapolis, MN

Find the ideal recipe for your mixture with high-powered statistical tools. \$1495\*

### Robust Design: DOE Tools for Reducing Variation

April 22–24: Minneapolis, MN

Use DOE to create products and processes robust to varying conditions. A must for six sigma. Factorial and RSM proficiency are required. \$1495\*

### Real-Life DOE

May 20–21: Minneapolis, MN

Learn advanced analysis tricks - how to deal with missing data, split plots and more. Factorial proficiency required. \$995\*

Attendance limited to 20. Reserve your place by calling Sherry at 800.801.7191 x18.

\*Includes a \$95 student materials charge which is subject to state and local taxes.



ABOUT STAT-EASE SOFTWARE, TRAINING, AND CONSULTING FOR DOE  
Phone 612.378.9449 Fax 612.378.2152 E-mail info@statease.com Web Site www.statease.com

## Play Putty Makes Mixture Design Simple and Fun

As the Stat-Ease staff of programmers looked on curiously, my partner Pat Whitcomb poured a beaker of borax solution into a container of white glue that I held under a revved-up malt mixer. Instantly the mixture thickened into a rubbery texture, climbed up the shaft and flung fingers of white goo around the company kitchen. The startled programmers beat a hasty retreat out the door as I belatedly hit the off switch. Pat and I heartily congratulated ourselves for mastering the art of making play putty. We two old chemical engineers still had the right stuff!

Let me explain what led two of Stat-Ease's principals to spend their valuable time and disrupt productivity by messing around with borax and glue. The story begins many years ago,



when Paul Sheldon of Honeywell International sent me instructions for an in-class experiment utilizing mixture design. His play-putty recipe languished in my files until recently, when an editor of "Rubber & Plastics News" magazine suggested I write an article on DOE. He asked that I keep it simple and make it fun via a playful example. Play putty, which behaves like a rubber in some respects, but like a soft plastic in others, seemed like the ideal candidate for me to experiment on.

Based on Paul's suggestions I laid out a mixture design aimed at making 100 milliliters (ml) of putty out of the following materials (amounts shown in parentheses):

A. borax (1-3 ml)

B. white glue (40-59 ml)

C. water (40-59 ml)

In this formulation, a chemical reaction occurs between a polymer (polyvinyl acetate in white glue) and a crosslinker (borax). Water participates as a solvent and modifies the physical properties

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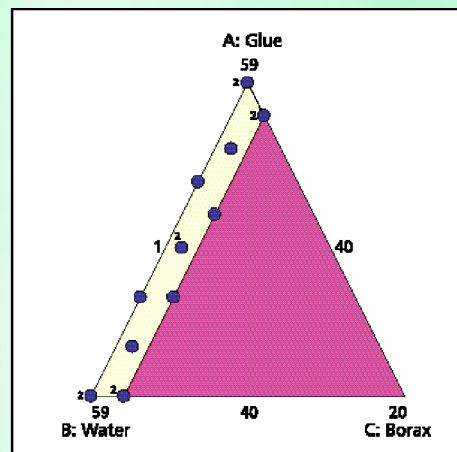


Fig. 1 - Mixture Design for Play Putty

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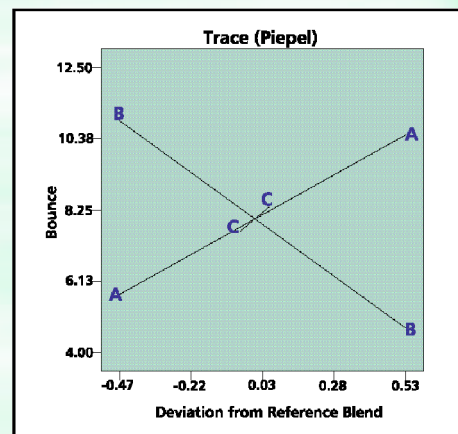
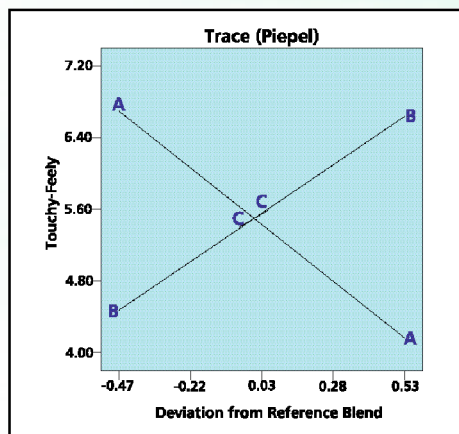
(rebound and deformability) of the resulting material.

Unfortunately, the cross-linking reaction goes very quickly, so it's difficult to get all the water into the newly-formed putty if you use a spoon to mix things up. This would not do for scientific purposes, so my partner Pat Whitcomb suggested I use his handy home malt mixer. (I hope his wife did not mind!) Our trial run in the company kitchen proved that this would work. Pat and I then traded designs back and forth and finally agreed on one that seemed doable.

The geometry of the design, constructed by filling the mixture space with blends spaced at relatively even intervals, can be seen in Figure 1. Notice that some points are labeled with the number "2." These represent blends to be replicated (in random run order) for estimation of pure error.

I toted Pat's mixer and the raw materials\* for play putty home and enlisted my youngest daughter Katie to be my laboratory assistant. We spent the better part of a Saturday making up the 16 blends. Katie kept begging to squeeze the play putty, but I made her zip them in labeled bags. After dinner I let her and several other family members do what I called the "touchy-feely" preference test. I then averaged their 1-worst to 10-best ratings and, with the aid of Design-Expert® software, analyzed it as one response from the mixture design.

Measurement of the second response required help from my next oldest, and much taller, daughter Carrie. She stood on a step-stool and dropped the balled-up blends of play putty from a height of 7 feet. I then measured how high the balls bounced while fending off the family dog, a very playful Golden



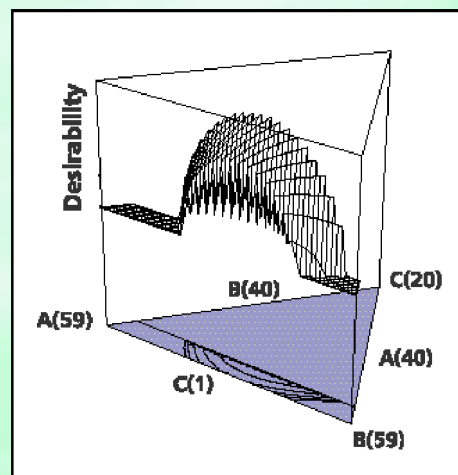
**Fig. 2 - Trace Plots for Touchy-Feely Rating & Bounce, Respectively**

Retriever named Penny. I'm not sure what would've happened if she had succeeded in getting her mouth around one of these gluey lumps. Luckily I made some great saves on the wild ricochets of the irregularly shaped play putty off the refrigerator before they landed in the waiting jaws of the 'wannabe' Retriever Penny.

For both the touch-feely rating and the bounce data I achieved linear mixture models with greater than 99.9% confidence and no significant lack of fit. The trace plots can be seen in Figure 2.

At first glance these look almost identical, but upon closer inspection you will notice that the ingredient labels A (borax) and B (glue) go opposite, which means that it's impossible to maximize both touchy-feely rating and bounce. When one response goes up, the other goes down, and vice-versa. I asked Design-Expert to help me find a desirable compromise via its numerical optimization feature. Figure 3 shows the result in 3D form.

The best recipe was 47 ml glue, 50 ml water and 3 ml borax according to the software. However, I noticed that it's hard to get that much borax into the solution so I advise backing off on it a bit to 2.5 ml, which equates to 1 teaspoon - a convenient measure for



**Fig. 3 - Desirability Plot**

kitchen experimentation. But don't take my word on this: Try it for yourself. This is a great experiment to do at home, especially if you're looking for an educational activity for children. The materials are non-toxic and water soluble, so clean-up poses no problems so long as you don't get carried away with high-powered mixers. My advice is to just use a spoon.

--Mark Anderson

\*To see detailed instructions on what materials to get, how to make them into play putty, and background on the chemistry, go to [www.statease.com/playputty.html](http://www.statease.com/playputty.html). At this site you will also find the Design-Expert data file from Mark's experiment.

# www.statease.net New Web Training!

Stat-Ease is pleased to announce the creation of a new statistical education web site at [www.statease.net](http://www.statease.net). Currently, this site features two educational opportunities for students.

## Statistics Self-Assessment

If you are interested in Stat-Ease's "Experiment Design Made Easy" workshop, but aren't sure you have the necessary statistical skills, you are encouraged to complete a FREE online self-assessment. This questionnaire will help you determine whether or not you are adequately prepared. It is for your benefit alone (we aren't keeping track), so please don't feel shy about taking it. If you find your skills are lacking, we invite you to sign up for our "PreDOE" online course in basic statistics (see below).

## PreDOE - Basic Statistics (\$195)

This self-paced, interactive online course is designed for those of you who have either not studied statistics before or who would like to review basic statistical concepts. It will take 3-6 hours to complete, depending on your familiarity with the



material. Once you successfully complete the course by passing the final assessment test with a score of 80% or higher, you will receive a certificate with 0.6 CEU's and a coupon code for \$100 discount on the "Experiment Design Made Easy" workshop.

## How Do You Start?

Log on to [www.statease.net](http://www.statease.net) and type in the word "public" and the password "online". This will take you to the registration screen. Click on the "New Student" button. On the next screen,

select either the "Statistics Self-Assessment" or "PreDOE - Basic Statistics" course option and enter your name and address information. After completing the registration process, instant access is provided for the "Statistics Self-Assessment" course. If you are signing up for "PreDOE - Basic Statistics", you will be prompted for payment details. Once your payment is processed, your enrollment will be immediately activated and you will have access to the course materials. E-mail [shari@statease.com](mailto:shari@statease.com) with any questions.

# PreDOE Syllabus

## Section 1: PreDOE Information Page

- ♦ Site Navigation
- ♦ How to Get Help
- ♦ Final Assessment Test

## Section 2: Statistical Thinking and Data Description

- ♦ Statistical Thinking
- ♦ Causes of Variation - Common and Special Causes
- ♦ Descriptive Statistics - Mean, Mode and Median
- ♦ Measuring Variation - Variance

and Standard Deviation

## Section 3: Normal Distribution/Central Limit Theorem

- ♦ Normal Distribution - area under the curve percentages
- ♦ Z-scores and Probability Calculations
- ♦ Testing for Normality - Histogram vs. Probability Paper
- ♦ Central Limit Theorem

## Section 4: Hypothesis Testing

- ♦ Hypothesis Testing Concepts
- ♦ Proposal

- ♦ Decision Criteria - Type I vs Type II errors
- ♦ Data Collection
- ♦ Drawing Conclusions

## Section 5: t-Testing

- ♦ t-Testing concepts
- ♦ Using a t-Table
- ♦ Using a t-Table vs. Statistical Software

## Section 6: Analysis of Variance

- ♦ Analysis of Variance (F-testing)
- ♦ Sums of Squares
- ♦ Degrees of freedom
- ♦ F-value

# Wanted: Case Study Articles from all Industries!

The use of designed experimentation is exploding in a variety of fields ranging from the biological, pharmaceutical and medical device industries to such non-traditional areas as healthcare and marketing. In the past, DOE has been applied in many fields, but its use has not been mainstream. Now, with the emphasis many companies are placing on Six Sigma practices, DOE is gaining recognition for the important tool it is. Stories of successful DOE's have filtered through to many researchers, engineers and managers who are very interested in seeing the application of this "new" concept.

Stat-Ease is searching for individuals or teams willing to share their success stories.

Anyone who has designed an experiment that has led to improvements in their products or processes is invited to contact us. Don't worry if it didn't go perfectly, as long as you learned something about the subject of interest. Perhaps you saved the company some money, or were able to make a product that met or surpassed customer requirements.

We can team you up with a technical writer who will coordinate the creation of the magazine article. You provide the interesting information and the technical writer provides the format. Plus, the technical writer does the work of submitting your case study to the appropriate magazines or journals. The article

is published with your name as author.

Do you have confidentiality issues? Don't worry, complete confidentiality can be maintained by disguising factor names or levels. We do this on a regular basis and the effectiveness of the article is not diminished.

Please consider showing off your DOE application! We continually get requests for examples of DOE applications in every field and industry. If you are interested in sharing your story, or just want more information, please contact [heidi@statease.com](mailto:heidi@statease.com). Heidi can also be reached at 1.612.378.9449 ext. 25. View previous case studies and articles at [www.statease.com/articles.html](http://www.statease.com/articles.html).

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E-mail me a link to the newsletter. I will view it on the web. (E-mail: \_\_\_\_\_),  Please remove me from your mailing list.

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