Design-Expert® Software: Why Version 9 is Mighty Fine!

What’s in it for You

Stat-Ease, Inc. welcomes you to version 9 (v9) of Design-Expert software (DX9) for design of experiments (DOE). Use this Windows®-based program to optimize your product or process. It provides many powerful statistical tools, such as:

- Two-level factorial screening designs: *Identify the vital factors that affect your process or product so you can make breakthrough improvements.*
- General factorial studies: *Discover the best combination of categorical factors, such as source versus type of raw material supply.*
- Response surface methods (RSM): *Find the optimal process settings to achieve peak performance.*
- Mixture design techniques: *Discover the ideal recipe for your product formulation.*
- Combinations of process factors, mixture components, and categorical factors: *Mix your cake (with different ingredients) and bake it too!*

Your Design-Expert program offers rotatable 3D plots to easily view response surfaces from all angles. Use your mouse to set flags and explore the contours on interactive 2D graphs. Our numerical optimization function finds maximum desirability for dozens of responses simultaneously!

You’ll find a wealth of statistical details within the program itself via various Help screens. Take advantage of this information gold-mine that is literally at your fingertips. Also, do not overlook the helpful annotations provided on all reports.

For a helpful collection of checklists and ‘cheat sheets,’ see the *Handbook for Experimenters*. It’s free to all registered users. Furthermore, for quick primers on the principles of design and analysis, we recommend you read the following two soft-cover books from Stat-Ease Principals Mark Anderson and Pat Whitcomb —published by Productivity Press of New York city:

- *DOE Simplified: Practical Tools for Effective Experimentation,*

Anderson and Whitcomb have also written a *Primer on Mixture Design*. It’s posted free for all to read via the “I’m a Formulator” link on the Stat-Ease home page.

Go to [http://www.statease.com/prodbook.html](http://www.statease.com/prodbook.html) for details and ordering information on the books listed above.

What’s New

Those of you who’ve used previous versions of Design-Expert software will be impressed with the many improvements in Version 9. Here are the highlights:

*Hard-to-change factors handled via split plots*

- Two-level, general and optimal factorial split-plot designs: *Make it far easier as a practical matter to experiment when some factors cannot be easily randomized.*
Getting started with v9 of Design-Expert software

- Half-normal selection of effects from split-plot experiments with test matrices that are balanced and orthogonal: The vital effects, both whole-plot (created for the hard-to-change factors) and sub-plot (factors that can be run in random order), become apparent at a glance!

- Effects from split plots assessed via REML* and Kenward-Roger’s approximate F test: See the familiar p-values that tell you what’s statistically significant.
  *(Restricted maximum likelihood)

- Design resolution provided for two-level factorial split plots: Assess from the start whether your choice suffices for screening main effects (Res IV) or characterizing interactions (Res V).

- Power calculated for split plots versus the alternative of complete randomization: See how accommodation of hard-to-change factors degrades the ability to detect certain effects.

- Check designs with restricted randomization for REML/OLS* equivalence: Keep things simple statistically (KISS) in the ANOVA.
  *(Ordinary least squares)

**Other new design capabilities**

- Definitive screening designs: If you want to cull out the vital few from many numeric process factors, this fractional three-level DOE choice resolves main effects clear of any two-factor interactions and squared terms (see screenshot of correlation matrix—more on that later).

- On the Factorial tab select a simple-sample design for mean-model only: Take advantage of powerful features in Design-Expert software for data characterization, diagnostics and graphics—for example with raw outputs from a process being run at steady-state.
**Much-improved capabilities to confirm or verify model predictions**

- New Post Analysis Node (at bottom of the handy tree structuring of Design, Analysis and Optimization) contains Point Prediction, Confirmation and Coefficients Table reports: *Old and new features gathered in logical place at the end of the natural progression from design through analysis.*

- Entry fields for confirmation data and calculation of mean results: *Makes it really easy to see if follow-up runs fall within the sample-size-adjusted prediction intervals.*

- Enter verification runs embedded within blocks as controls or appended to your completed design: *Lend veracity to your ultimate model by these internal checks.*

- Verification points displayed on model graphs and raw residual diagnostics: *See how closely these agree to what’s predicted by your model.*

**New and more-informative graphics**

- Adjustably-tuned LOESS fit line for Graph Columns: *Draw a curve through a non-linear set of points as you see fit.*
  *(Locally weighted scatterplot smoothing.)*
• Color-coded correlation grid for graph columns: *Identify at a glance any factors that are not controlled independently of each other, that is, orthogonally; also useful for seeing how one response correlates to another.* *(Data shown in screen shot comes from historical data detailed in RSM Simplified on NFL sacks versus attributes of defensive linemen.)*

• Jump to run added to Factors Tool for model graphs: *For multidimensional experimental regions, find the slice of interest (containing the point you want to see) at the press of a button.*

• When jumping to a run, the range expands to include the design point: *Use this feature to check how well your model fits—comparing the actual result versus what is predicted via the surface graph (in this case very well—the circled red point is barely beneath the surface).*

• Ignored (and missing) runs can be shown on graphs: *Good to be reminded that the original design called for this, but for one reason or another, you ignored the outcome (or the response could not be collected, or it was skipped).*

• Choice to do diagnostic graphs with externally-studentized residuals (now the default): *This deletion-diagnostic (vs internally-studentized) provides a more sensitive view of potential abnormalities.*
Many new icons, such as ones for Clear Points and Pop-Out View on the Diagnostics Tool: Jump to features used frequently more quickly via these handy markers (also they look good!).

Three-component contour graphs in reals: Get a better view of the restrictions placed on your mixture space by the constraints you enter on each component and the total.

Half-normal plot for one-factor categorical experiments with replicates: See at a glance if anything significant emerges.

Greater flexibility in data display and export

Descending sort of all individual design layout columns via right-click menu (shown) or double-click on header (toggles with ascending sort—previously the only option): Helpful, for example, when minimum response is desired.

Identify via “Build Type” the predetermined Model, Lack of Fit, Center, and Replicate points in your design layout: Dissect the matrix laid out for optimal (I, D, etc) experiments.

Switch directly between continuous and discrete point type: Sometimes the settings for a factor cannot be easily changed (for example, diameter of molded part)—then it pays to recognize them as discrete, thus enabling the numeric optimizer being set so it will not stray away from specific values.

Ignorable block and/or factor columns: Handy for “what-if” analysis, such as what would have happened if you had not blocked your experiment.
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- Journal feature to export data directly to Microsoft Word or Powerpoint: *Fast and formatted for you to quickly generate a presentable report on your experimental results.*

- Improved copy/paste of Final Equation from the analysis of variance (ANOVA) report to Microsoft Excel: *This not only saves tedious transcription of coefficients but it also sets up a calculator for you to ‘plug and chug’, that is, enter into the spreadsheet cells what values for the inputs you’d like to evaluate and see what the model predicts for your response.*

- From Evaluation and ANOVA screens, the X matrix can be viewed and exported: *This is helpful, for example, for copy and paste to R or Matlab where statisticians can do further manipulations for research purposes.*

- Display full precision of F-test: *If just presenting p<0.0001 is not precise enough, show all the decimals.*

- New XML* script commands for exporting point predictions: *Helpful for situations where one wants to automate the transfer of vital outputs from Design-Expert to other programs.*

*(Extensible Markup Language)*

**More powerful tools for modeling**

- Design model included in Fit Summary: *This can be very helpful for combined designs such as response surface optimizations that include categorical factors (in this case recommending a model that included some cross-product terms of 3rd order, which provided a better fit of the data).*
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- All-hierarchical model (AHM) selection: Sort through all possible models up to the one you designed the experiment for, but all the while maintain hierarchy of terms so you do not end up with something ill-formulated. (PS. The alpha out is enforced after AHM is completed by doing a final sweep using backward selection, after which hierarchy is again corrected by the program.)

- Non-linear equations involving trigonometric, exponential and other functions allowed for creating deterministic responses (for example—costs) or simulations: This will be especially helpful for setting up more realistic scenarios for students to solve during hands-on workshops for teaching DOE. (PS. Simulator now provides an entry field for ratio of variance between whole and sub plots so trainers can set up split-plot exercises.)

- Special quartic Scheffé polynomial included in automatic selection for mixture modeling: Sometimes this added degree (4\textsuperscript{th}) of non-linear blending helps to better shape the response surface—making it better for predictive purposes.

More choices when custom-designing your experiment

- Required model points set aside from optional additional ones that may be needed for adequate sizing of the design: Prevents setting up an experiment with too few points to fit the chosen model.

- Enter a single factor constraint for response surface designs: Creates a 'hard' limit on inputs that cannot go beyond a certain point (such as zero time) physically or operationally.
Greater flexibility in setting up models: For example you can now create an optimal model for experiment on mixtures with varying categorical ingredients, some of which can go to zero.* *(See presentation of “Categoric Mixture Components Proportion Going to Zero” by Pat Whitcomb, ENBIS-12, Ljubljana, Slovenia. Slides available on request to stathelp@statease.com.)

Save candidate sets in actuals: More flexibility for customizing your experiment design.

**More capability for numerical optimization**

- Include $C_{pk}$* as a goal: Meet quality goals explicitly. *(A process capability index widely used for Six Sigma and Design for Six Sigma programs.)*

**Enhanced design evaluation**

- Random model generator provided to generate a realistic response via a quadratic polynomial with coefficients picked by chance: Use this to play around with how the software presents the analysis—better than just generating random numbers that only fit a mean model.

- One-sided option added to FDS* graph: Size your design properly for a verification experiment done to create a QBD** design space. *(Fraction of design space)*
  *(Quality by Design—a protocol promoted by the US Food & Drug Administration (FDA).)*

**Many things made nicer, easier, more configurable and faster**

- Components that do not vary in a mixture experiment can now be included in the design build—see them highlighted with gray in the layout: Provide a recipe sheet that encompasses the entire formulation, not just what will be manipulated in your study.

- Automatically re-sort by run order after re-randomizing: A little feature that saves users a bother.

- Diagnostics report now can be sorted by any of the statistics listed: This enables a more informative ordering than by run number (the default).

- Faster display of graphs: Great for dazzling your audience with 3D graphs in high resolution.
Pop-out views numbered: *Makes it easier to distinguish and find the associated view-Tool when re-arranging on your desktop.*

Graph state stored with file: *Restores setting to the way you liked them.*

Improved graphics on Transformation screen: *Looks more elegant—better to show off your results via live presentations or webinars.*

Fonts on analysis tabs now configurable under Edit Preferences (Dialog Control): *Go ahead and make them Comic Sans if you would like to lighten things up. :)*

**Safety net expanded—more mistakes caught and ‘heads-ups’ given**

- Warning when largest effect not selected on half-normal plot: *This would not make sense, but it might happen due to, for example, not lassoing points correctly.*

- Hover Help added to select fields: *When your mouse goes over an entry place, the program fills you in with a bit more information on what’s entailed in the feature you are specifying.*
**Niceties that only statisticians might truly appreciate**

- Mean correction for transformation bias when responses displayed in original scale: *All you need to know is that our statisticians figured out how to eliminate a tricky, little-known bias!*

- Propagation of error (POE) carried out to the second derivative: *Makes POE more accurate.*

- Display confidence bands with or without POE added: *Easier to match output with other programs that do not offer POE features like this.*

- Add unblocked results to evaluation of blocked experiments: *Aids in comparing designs on the basis of matrix measures.*

- Scale to largest estimable effect those normal effects that cannot be otherwise estimated: *This can happen when effects become too large compared to the error estimated by chi-square.*

- Preference now available to display p values to full precision: *Previously the program restricted p values to four decimals, which in some cases did not go far enough.*

**Technical stuff only those adept at programming will ‘get’**

- Automatically generate DTD* files: *Now these will always be up to date.* *(Document Type Definition)*

- New command to export runs of a specific type: *Particularly useful for verification points.*

**Good news for network administrators**

- New more flexible and easier-to-use license manager with greater power to serve enterprise users: *For example, network ‘seats’ can be checked out to individual laptops and multiple opening of the program on a specific computer will only use one seat.*