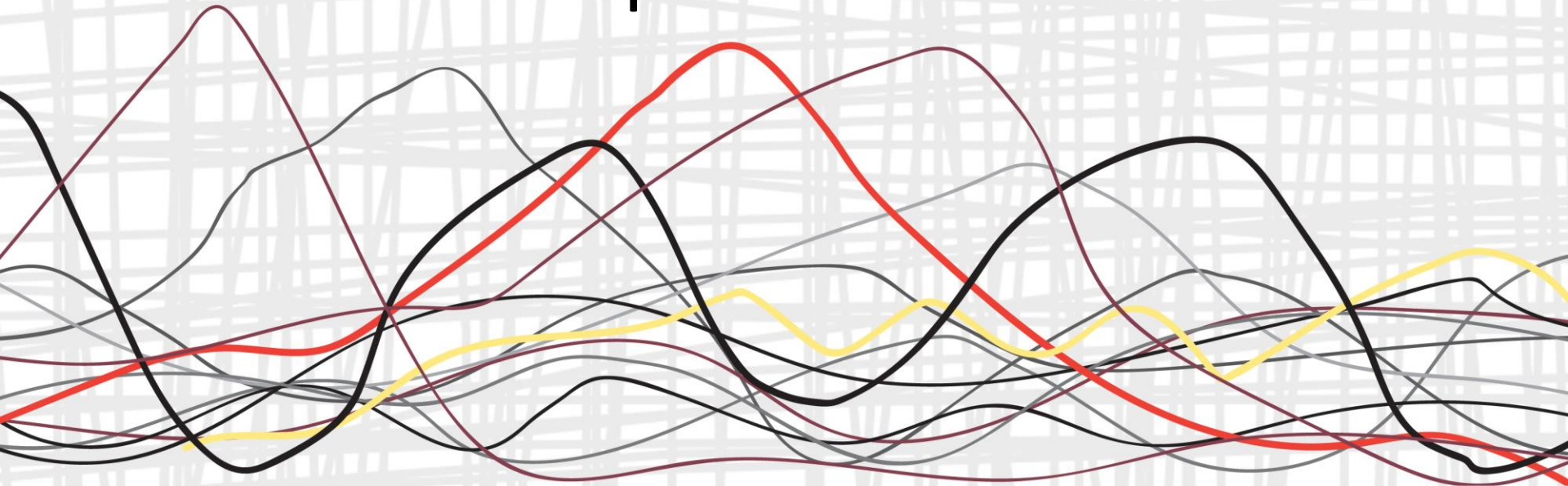


The logo for Statgraphics 19, featuring a stylized grid of squares in dark red and a yellow diamond shape.

statgraphics 19[®]

Enhancements to the Design of
Experiments



Statgraphics 19 DOE Enhancements

Construction of Alias Optimal Designs

- Computer generated designs
- Maximize design efficiency while minimizing aliasing due to terms not in the current model

Augmentation of Existing Designs in an Optimal Manner

- Adds additional runs so as to maximize design efficiency

Typical Screening Design for 6 Factors

Design of Experiments Wizard - Select Design

Design file: <untitled>

Comment:

Robust Parameter Design

- Combined array
- Crossed array

	Segment	Factors	Runs	Blocks	Design
<input type="button" value="Options..."/>	Process factors	6	12	1	Plackett-Burman $2^{6*3/16}$
<input type="button" value="Options..."/>	Mixture components	0	0	0	
<input type="button" value="Options..."/>		0	0	0	
	COMBINED	6	12	1	Samples per run: <input type="text" value="1"/>

	BLOCK	Factor_A	Factor_B	Factor_C	Factor_D	Factor_E	
1	1	-1.0	1.0	1.0	-1.0	1.0	-1.0
2	1	1.0	-1.0	-1.0	-1.0	1.0	1.0
3	1	-1.0	1.0	1.0	1.0	-1.0	1.0
4	1	1.0	-1.0	1.0	1.0	-1.0	1.0
5	1	1.0	-1.0	1.0	-1.0	-1.0	-1.0
6	1	1.0	1.0	-1.0	1.0	-1.0	-1.0
7	1	1.0	1.0	-1.0	1.0	1.0	-1.0
8	1	-1.0	-1.0	1.0	1.0	1.0	-1.0
9	1	1.0	1.0	1.0	-1.0	1.0	1.0
10	1	-1.0	-1.0	-1.0	1.0	1.0	1.0
11	1	-1.0	1.0	-1.0	-1.0	-1.0	1.0
12	1	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0

Alias Matrix for Typical Design

Experimental Design Wizard

Step 1: Define responses Step 3: Select design Step 5: Select runs Step 7: Save experiment Step 9: Optimize responses Step 11: Augment design
Step 2: Define exp. factors Step 4: Specify model Step 6: Evaluate design Step 8: Analyze data Step 10: Save results Step 12: Extrapolate

Alias Matrix

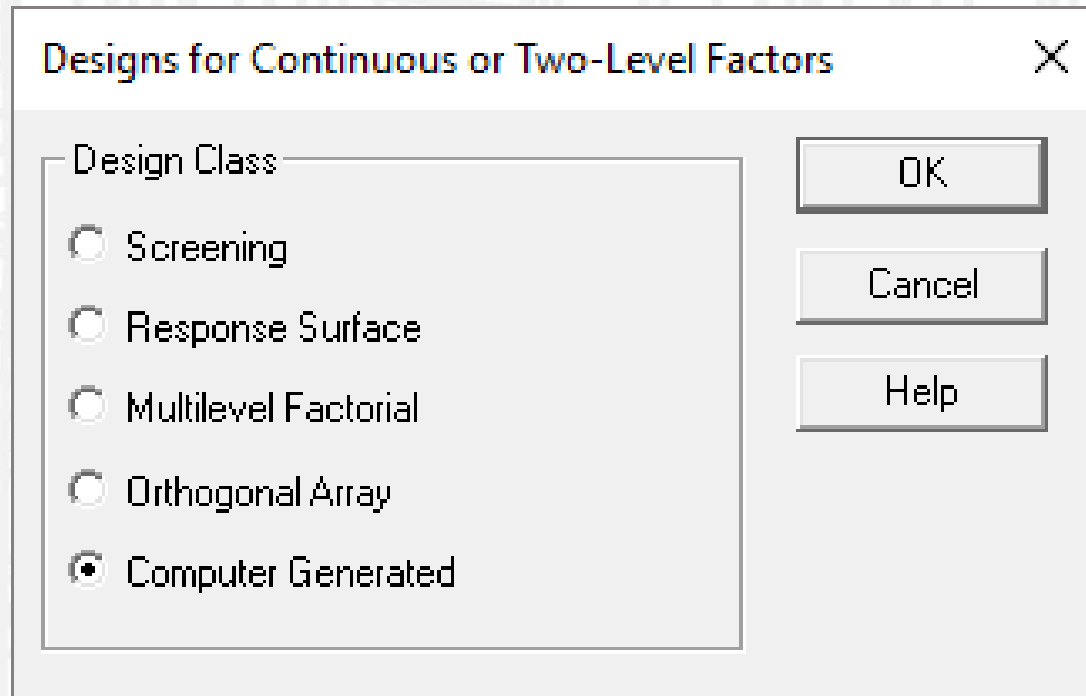
Effect	AB	AC	AD	AE	AF	BC	BD	BE	BF	CD
constant										
A						-0.3333	0.3333	0.3333	-0.3333	-0.3333
B		-0.3333	0.3333	0.3333	-0.3333					-0.3333
C	-0.3333		-0.3333	-0.3333	0.3333		-0.3333	0.3333	0.3333	
D	0.3333	-0.3333		-0.3333	-0.3333	-0.3333		-0.3333	-0.3333	
E	0.3333	-0.3333	-0.3333		0.3333	0.3333	-0.3333		-0.3333	-0.3333
F	-0.3333	0.3333	-0.3333	0.3333		0.3333	-0.3333	-0.3333		0.3333

$\text{tr}(A'A)=6.6667$

The StatAdvisor

The alias matrix indicates the extent to which the effects to be estimated are confounded with effects that are not in the current model. Each row represents an effect to be estimated. A non-zero value in any cell indicates that the effect in the corresponding column, multiplied by the value in the cell, is added to the estimated effect when the model is fit. You can use Analysis Options to change which effects are included in the model and Pane Options to select the maximum order for any confounded effects.

Constructing an Alias Optimal Design



Constructing an Alias Optimal Design

DOE Wizard Model Options

Process Factors Model

- Mean
- Linear (Main Effects)
- 2-Factor Interactions
- Quadratic
- Cubic

Mixture Components Model

- Mean
- Linear
- Quadratic
- Special Cubic
- Cubic

Include:

A:Factor_A
B:Factor_B
C:Factor_C
D:Factor_D
E:Factor_E
F:Factor_F

Exclude:

OK

Cancel

Help

Constructing an Alias Optimal Design

Computer Generated Designs

	BLOCK	Factor_A	Factor_B	Factor_C	Factor_D	Factor_E
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						

Optimize

- I-efficiency
- D-efficiency
- A-efficiency
- G-efficiency
- Alias-efficiency

Display

- Original units
- Coded units

Randomize run order

Alias options

Number of coefficients: 7

Number of base runs:

Number of replicates:

Number of centerpoints:

Group runs in blocks of size:

OK

Cancel

Help

Create

Advanced

Constructing an Alias Optimal Design

Alias Optimal Design Options ✕

Potential Model

- 2-factor interactions
- Quadratic terms
- 3-factor interactions
- Cubic terms
- Mixed third-order terms

OK

Cancel

Help

Minimum relative D-efficiency:

Number of alias reduction attempts:

Constructing an Alias Optimal Design

Computer Generated Designs

	BLOCK	Factor_A	Factor_B	Factor_C	Factor_D	Factor_E	Factor_F
1	1	-1.0	1.0	1.0	-1.0	1.0	1.0
2	1	1.0	1.0	1.0	1.0	-1.0	-1.0
3	1	1.0	1.0	-1.0	-1.0	-1.0	0.5
4	1	-1.0	-1.0	-1.0	-1.0	1.0	1.0
5	1	-1.0	1.0	-1.0	-1.0	1.0	-1.0
6	1	1.0	-1.0	1.0	1.0	-1.0	1.0
7	1	1.0	1.0	-1.0	1.0	1.0	1.0
8	1	-1.0	-1.0	1.0	1.0	1.0	-0.5
9	1	-1.0	1.0	-1.0	1.0	-1.0	1.0
10	1	1.0	-1.0	1.0	-1.0	1.0	-1.0
11	1	1.0	-1.0	-1.0	1.0	-1.0	-1.0
12	1	-1.0	-1.0	1.0	-1.0	-1.0	-1.0
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							

Optimize
 I-efficiency
 D-efficiency
 A-efficiency
 G-efficiency
 Alias-efficiency

Display
 Original units
 Coded units
 Randomize run order
Alias options

Number of coefficients: 7
Number of base runs: 12
Number of replicates: 0
Number of centerpoints: 0
 Group runs in blocks of size: 1000

Average prediction variance: 0.286934
D-efficiency: 90.45%
A-efficiency: 84.04%
trace(A'A): 0.590278

Create Advanced

OK
Cancel
Help

Alias Matrix for Alias Optimal Design

Experimental Design Wizard

Step 1: Define responses Step 3: Select design Step 5: Select runs Step 7: Save experiment Step 9: Optimize responses Step 11: Augment design
 Step 2: Define exp. factors Step 4: Specify model Step 6: Evaluate design Step 8: Analyze data Step 10: Save results Step 12: Extrapolate

Alias Matrix

Effect	AB	AC	AD	AE	AF	BC	BD	BE	BF	CD	CE	CF	DE	DF
constant			0.3333	-0.3333	-0.0833	-0.3333			0.2500			-0.2500	-0.3333	0.0833
A														
B														
C														
D														
E														
F														

$\text{tr}(A'A) = 0.590278$

The StatAdvisor
 The alias matrix indicates the extent to which the effects to be estimated are confounded with effects that are not in the current model. Each row represents an effect to be estimated. A non-zero value in any cell indicates that the effect in the corresponding column, multiplied by the value in the cell, is added to the estimated effect when the model is fit. You can use Analysis Options to change which effects are included in the model and Pane Options to select the maximum order for any confounded effects.

Variance Inflation Factors

Experimental Design Wizard

Step 1: Define responses Step 3: Select design Step 5: Select runs Step 7: Save experiment Step 9: Optimize responses Step 11: Augment design
 Step 2: Define exp. factors Step 4: Specify model Step 6: Evaluate design Step 8: Analyze data Step 10: Save results Step 12: Extrapolate

Model Coefficients

Coefficient	Standard Error	VIF	Ri-Squared	Power at SN = 0.5	Power at SN = 1.0	Power at SN = 2.0
constant	0.288675			10.97%	29.15%	78.91%
A	0.317975	1.2133	0.175799	9.91%	24.96%	71.16%
B	0.312483	1.17175	0.146572	10.08%	25.66%	72.59%
C	0.312483	1.17175	0.146572	10.08%	25.66%	72.59%
D	0.320145	1.22992	0.186937	9.84%	24.69%	70.59%
E	0.317975	1.2133	0.175799	9.91%	24.96%	71.16%
F	0.332871	1.16343	0.140476	9.47%	23.22%	67.33%

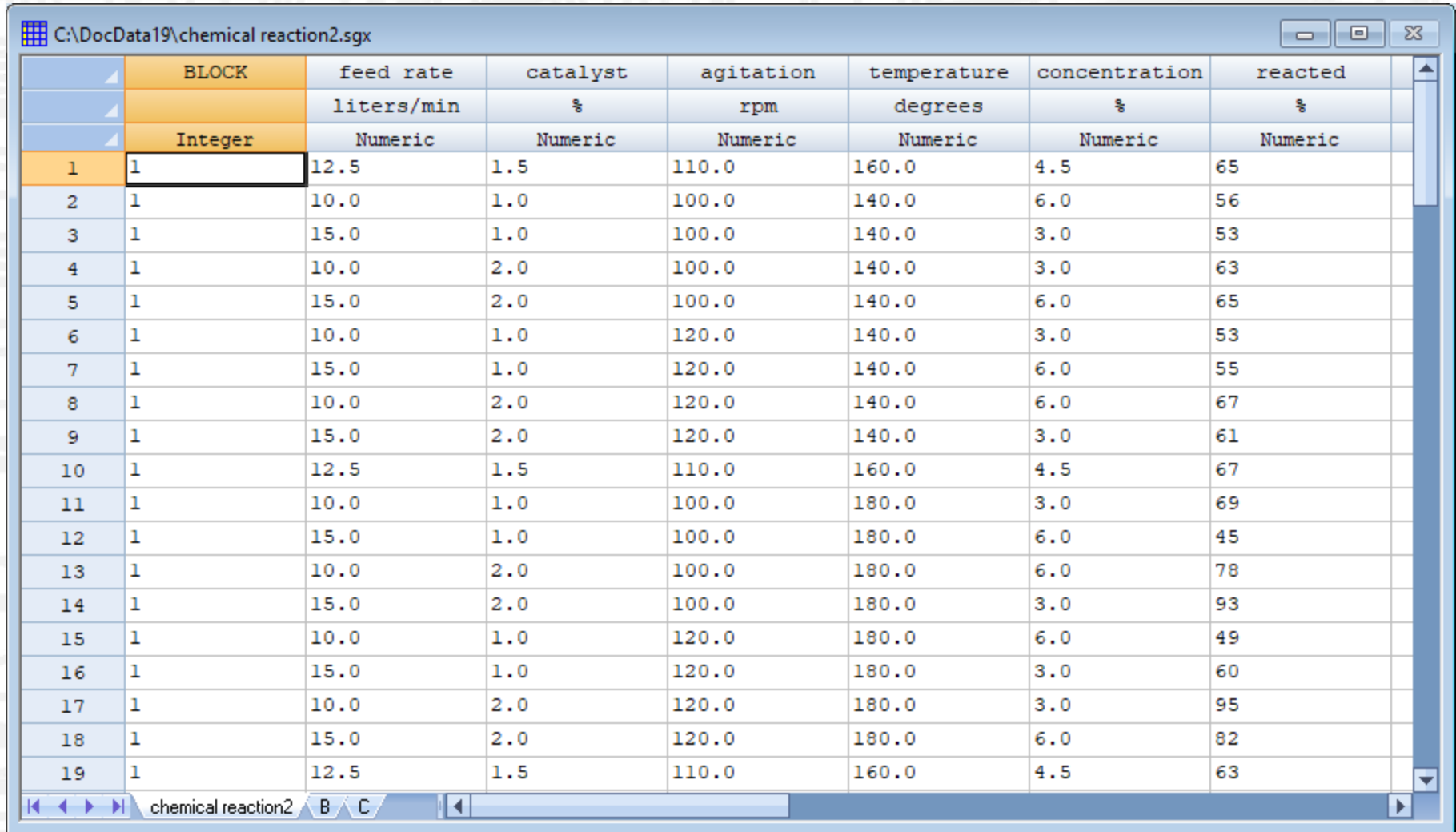
alpha = 5.0%, sigma estimated from total error with 5 d.f.

The StatAdvisor

This table shows the standard errors of the coefficients in the model to be fit, as a multiple of the experimental error sigma. The smaller the standard error, the more precise the estimates of the coefficients will be. Also included are variance inflation factors, which measure the extent to which the variance of the estimated coefficients is inflated due to lack of orthogonality in the design. VIF's above 10, of which there are 0, are usually considered to indicate serious non-orthogonality. A related statistic, Ri-Squared, measures the extent to which a coefficient is correlated with other coefficients.

The table also shows the power of the design for each effect. Power is defined as the probability of identifying an effect of a given magnitude as being statistically significant when the data are analyzed. It is shown for 3 signal-to-noise ratios, where SN is defined as twice the magnitude of the regression coefficient divided by the standard deviation of the experimental error. For

Augmenting Existing Designs

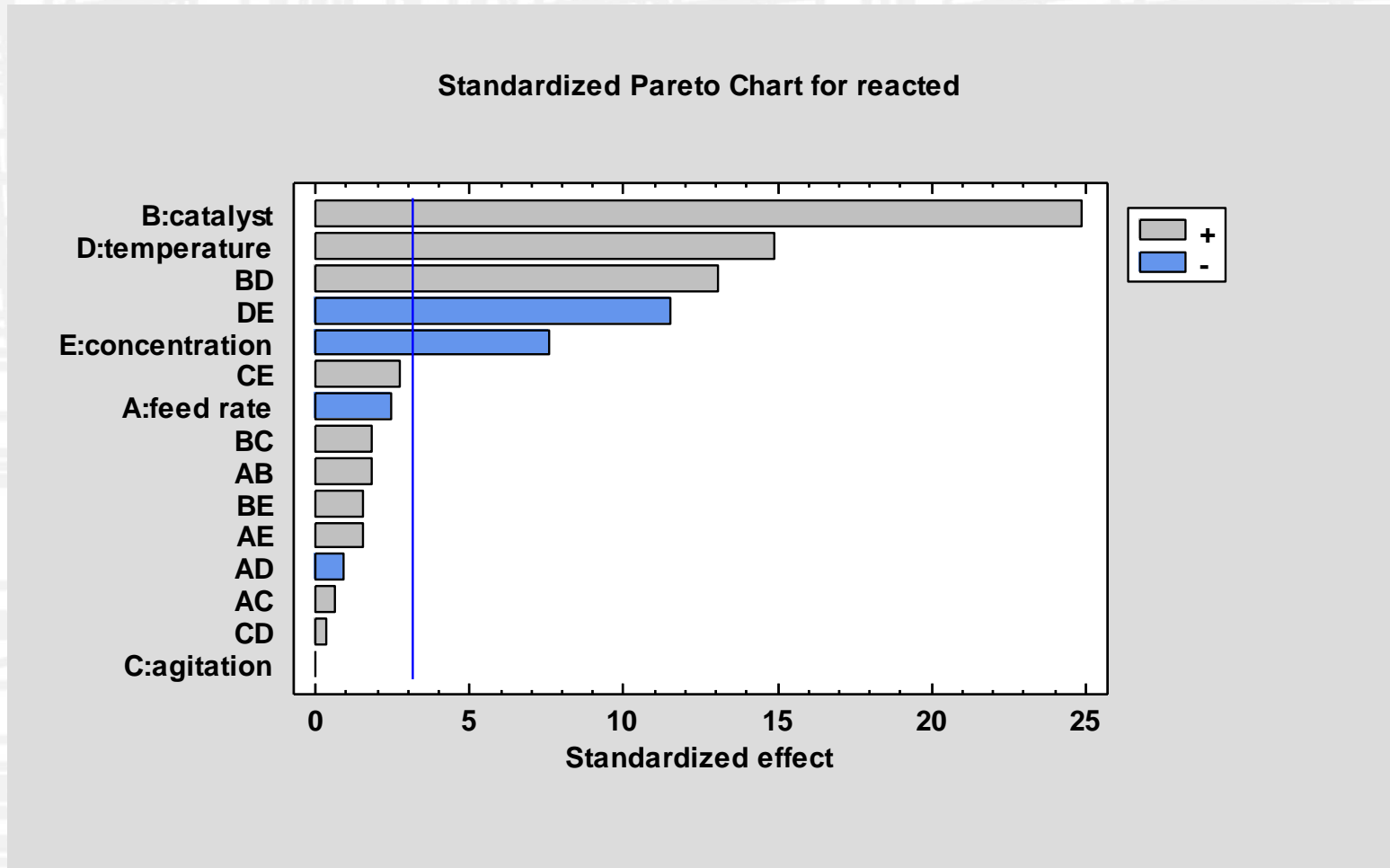


C:\DocData19\chemical reaction2.sgx

	BLOCK	feed rate	catalyst	agitation	temperature	concentration	reacted
		liters/min	%	rpm	degrees	%	%
	Integer	Numeric	Numeric	Numeric	Numeric	Numeric	Numeric
1	1	12.5	1.5	110.0	160.0	4.5	65
2	1	10.0	1.0	100.0	140.0	6.0	56
3	1	15.0	1.0	100.0	140.0	3.0	53
4	1	10.0	2.0	100.0	140.0	3.0	63
5	1	15.0	2.0	100.0	140.0	6.0	65
6	1	10.0	1.0	120.0	140.0	3.0	53
7	1	15.0	1.0	120.0	140.0	6.0	55
8	1	10.0	2.0	120.0	140.0	6.0	67
9	1	15.0	2.0	120.0	140.0	3.0	61
10	1	12.5	1.5	110.0	160.0	4.5	67
11	1	10.0	1.0	100.0	180.0	3.0	69
12	1	15.0	1.0	100.0	180.0	6.0	45
13	1	10.0	2.0	100.0	180.0	6.0	78
14	1	15.0	2.0	100.0	180.0	3.0	93
15	1	10.0	1.0	120.0	180.0	6.0	49
16	1	15.0	1.0	120.0	180.0	3.0	60
17	1	10.0	2.0	120.0	180.0	3.0	95
18	1	15.0	2.0	120.0	180.0	6.0	82
19	1	12.5	1.5	110.0	160.0	4.5	63

chemical reaction2 B C

Pareto Chart for Original Design



Augment Design Step

Design of Experiments Wizard - Augment Design

BLOCK	feed rate liters/min	catalyst %	agitation rpm	temperature degrees	concentration %
1	12.5	1.5	110.0	160.0	4.5
2	10.0	1.0	100.0	140.0	6.0
3	15.0	1.0	100.0	140.0	3.0
4	10.0	2.0	100.0	140.0	3.0
5	15.0	2.0	100.0	140.0	6.0
6	10.0	1.0	120.0	140.0	3.0
7	15.0	1.0	120.0	140.0	6.0
8	10.0	2.0	120.0	140.0	6.0
9	15.0	2.0	120.0	140.0	3.0
10	12.5	1.5	110.0	160.0	4.5
11	10.0	1.0	100.0	180.0	3.0
12	15.0	1.0	100.0	180.0	6.0
13	10.0	2.0	100.0	180.0	6.0

Action

Add replicates:

Add a fraction

Clear main effects

Clear a factor: clear

Add star points

Optimize Add runs Search options New model

Total runs: 19
Total blocks: 1
Coefficients in model: 16

OK Cancel Reset Help

Specify New Model

DOE Wizard Model Options ✕

<p>Process Factors Model</p> <p><input type="radio"/> Mean</p> <p><input type="radio"/> Linear (Main Effects)</p> <p><input type="radio"/> 2-Factor Interactions</p> <p><input checked="" type="radio"/> Quadratic</p> <p><input type="radio"/> Cubic</p>	<p>Mixture Components Model</p> <p><input checked="" type="radio"/> Mean</p> <p><input type="radio"/> Linear</p> <p><input type="radio"/> Quadratic</p> <p><input type="radio"/> Special Cubic</p> <p><input type="radio"/> Cubic</p>	<p>OK</p> <p>Cancel</p> <p>Help</p>
---	---	-------------------------------------

Include:

B:catalyst
D:temperature
E:concentration
BB
BD
BE
DD
DE
EE

Exclude:

A:feed rate
C:agitation
AA
AB
AC
AD
AE
BC
CC
CD
CE

Specify Search Options

Computer Augmented Design Options ✕

Optimize

I-efficiency

D-efficiency

A-efficiency

G-efficiency

Number of continuous factor levels to consider:

Mixture increment between levels:

Create new block

Number of random starts:

Maximum iterations per start:

Augmented Design

Design of Experiments Wizard - Augment Design

BLOCK	feed rate liters/min	catalyst %	agitation rpm	temperature degrees	concentration %
13	10.0	2.0	100.0	180.0	6.0
14	15.0	2.0	100.0	180.0	3.0
15	10.0	1.0	120.0	180.0	6.0
16	15.0	1.0	120.0	180.0	3.0
17	10.0	2.0	120.0	180.0	3.0
18	15.0	2.0	120.0	180.0	6.0
19	12.5	1.5	110.0	160.0	4.5
20	12.5	1.0	110.0	180.0	4.5
21	12.5	1.0	110.0	160.0	3.0
22	12.5	1.5	110.0	180.0	3.0
23	12.5	2.0	110.0	160.0	3.0
24	12.5	2.0	110.0	180.0	4.5
25	12.5	1.5	110.0	140.0	3.0

Action

Add replicates:

Add a fraction

Clear main effects

Clear a factor: clear

Add star points

Optimize Add runs Search options New model

Total runs: 25
Total blocks: 1
Coefficients in model: 10

D-efficiency: 44.61%
G-efficiency: 38.17%
A-efficiency: 21.96%
Average prediction variance: 0.250949

OK Cancel Reset Help

More Videos

Videos are available to learn more about each of the new features.

You'll find them at:

www.statgraphics.com/instructional_videos

Also check our website for upcoming webinars.