CHAPTER 8

STATAPULT EXAMPLE

Introduction

The purpose of this chapter is to walk the user through a detailed example. We will use the statapult example found in *Straight Talk on Designing Experiments*. Figure 8-1 illustrates the basic setup for the Statapult. (If you are interested, statapults may be purchased through Launsby Consulting at 1-800-788-4363.)

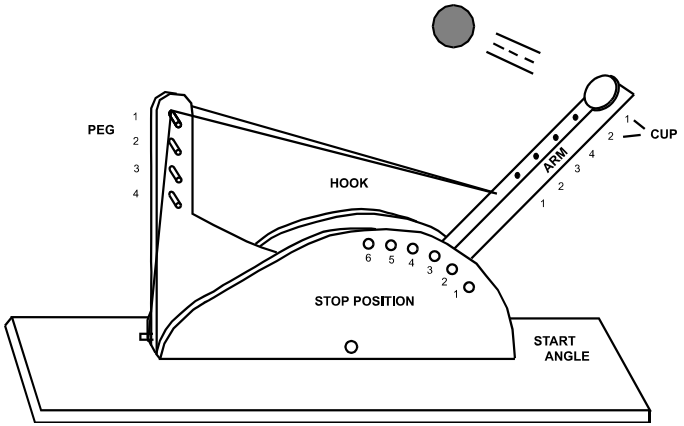


Figure 8-1

Project Window

Once Windows™ 95 or NT has been opened and DOE Wisdom has been selected from **Programs**, a screen similar to the one shown in Figure 8-2 will appear.

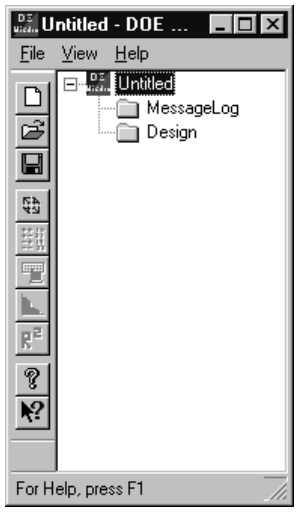


Figure 8-2

Click **File** on the menu bar. Select **New**. The **File New dialog box** will appear. Enter the name for the new experiment. For our example, we will use the name “statapult”.

Design Definition Dialog Box

Double-click on the **Design** folder in the **Project** window or click the **Design** button. The Design Definition Dialog Box shown in Figure 8-3 will appear.

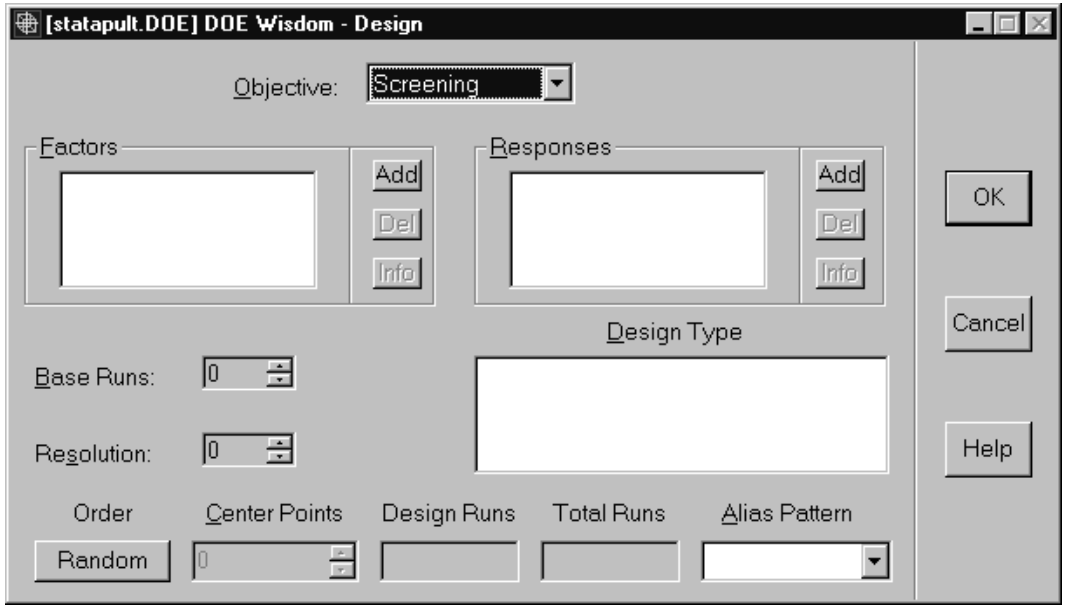


Figure 8-3

Objective

In our statapult example, we wish to optimize the in-flight distance of the ball. We would like to conduct a screening experiment with the three factors (Pull Back Angle, Hook Position, and Peg Position) at different settings and record the in-flight distance for each combination.

Click on the arrow at the right of the drop-down **Objective** list box to display all possible objective types. Select **Screening**.

Defining the Factors

The three factors for our experiment will be Pull Back Angle, Hook Position and Peg Position. In the Factor box, click on **Add**. The window shown in Figure 8-4 will appear.

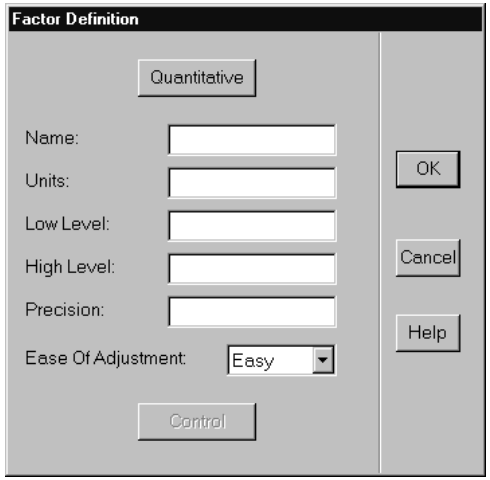


Figure 8-4

All the factors in this experiment will be quantitative factors. Tab to the factor **Name** section. Type **Pull Back**. Tab to the **Units** section and type **degrees**. Tab to the **Low Level** section and type **440**. Tab to the **High Level** section and type **490**. Tab to the **Precision** section and type **1**. The **Ease of Adjustment** will be **Easy**.

After all items have been entered, the screen for Pull Back will appear as shown in Figure 8-5.

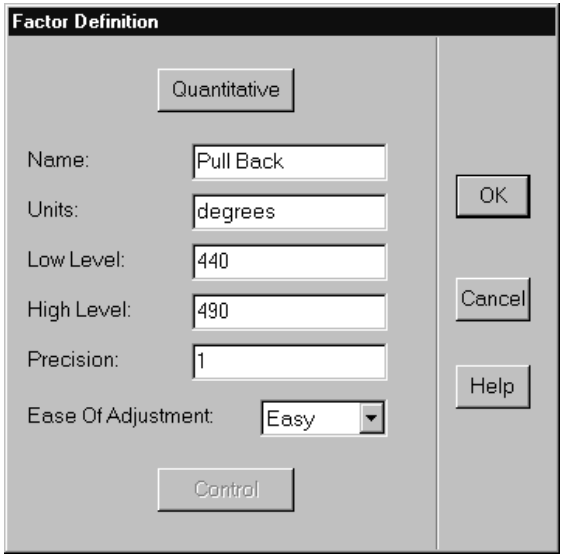


Figure 8-5

Choose **OK**. The factor "Pull Back" will now appear in the Factor List Box.

Click on **Add** in the Factor Box. Tab to the factor **Name** section and type **Hook**. The **Units** section will be left blank for this factor. Tab to the **Low Level** section and type **1**. Tab to the **High Level** section and type **5**. Tab to the **Precision** section and type **1**. The **Ease of Adjustment** will be **Easy**.

After all items have been entered, the screen for Hook will appear as shown in Figure 8-6.

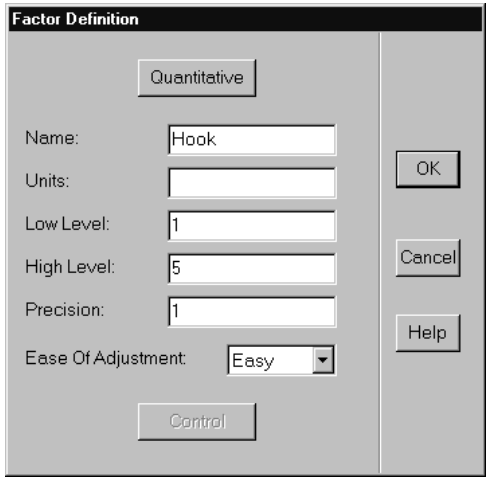


Figure 8-6

Choose **OK**. The factor "Hook" will now appear in the Factor List Box.

Click on **Add** in the Factor box. Tab to the factor **Name** section and type **Peg**. The **Units** section will be left blank for this factor. Tab to the **Low Level** section and type **1**. Tab to the **High Level** section and type **4**. Tab to the **Precision** section and type **1**. The **Ease of Adjustment** setting will be **Easy**.

After all items have been entered, the screen for Peg will appear as shown in Figure 8-7.

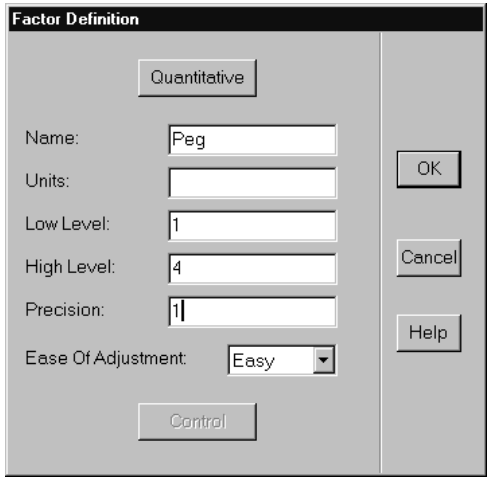


Figure 8-7

Choose **OK** and the factor "Peg" will now appear in the Factor List Box.

Defining the Response

The in-flight distance of the ball is the response for this experiment. In the Response Box, click on **Add**. The window in Figure 8-8 will appear.

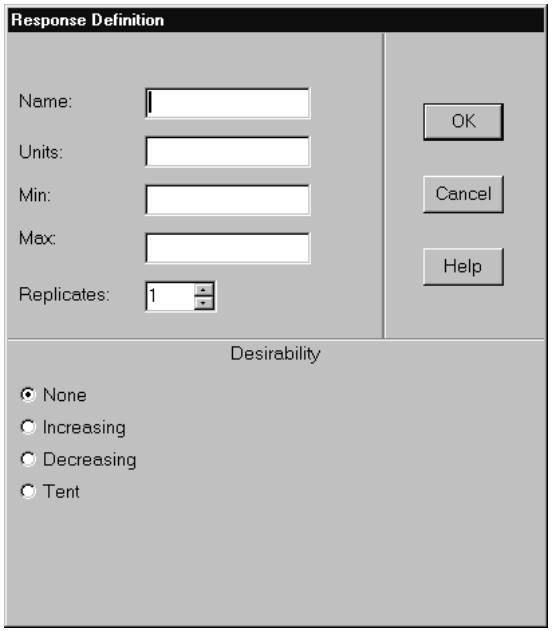


Figure 8-8

Type **Distance** in the **Name** section. Tab to the **Units** section and type **inches**. Tab to the **Min** section and type **30**. Tab to the **Max** section and type **230**. Click on the arrow at the right of the **Replicates** section to indicate **3** replicates.

After all items have been entered, the screen for "Distance" will appear as shown in Figure 8-9.

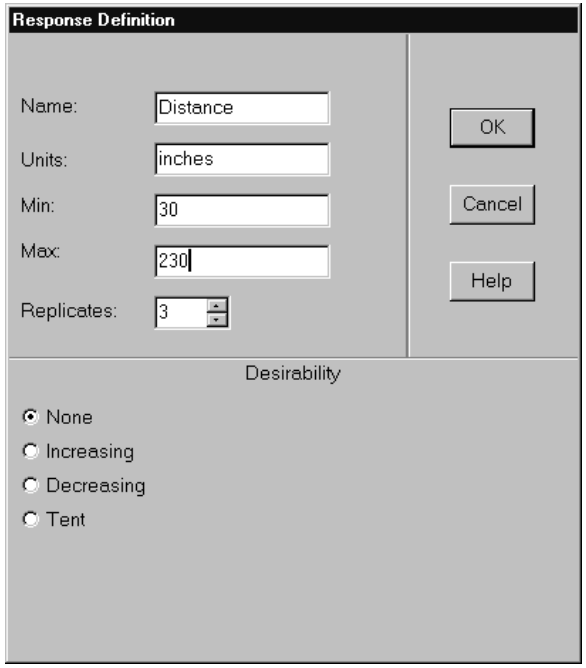


Figure 8-9

Choose **OK** in the Response box and the response "Distance" will now appear in the Response Box. The Design Definition Screen will now appear as shown in figure 8-10.

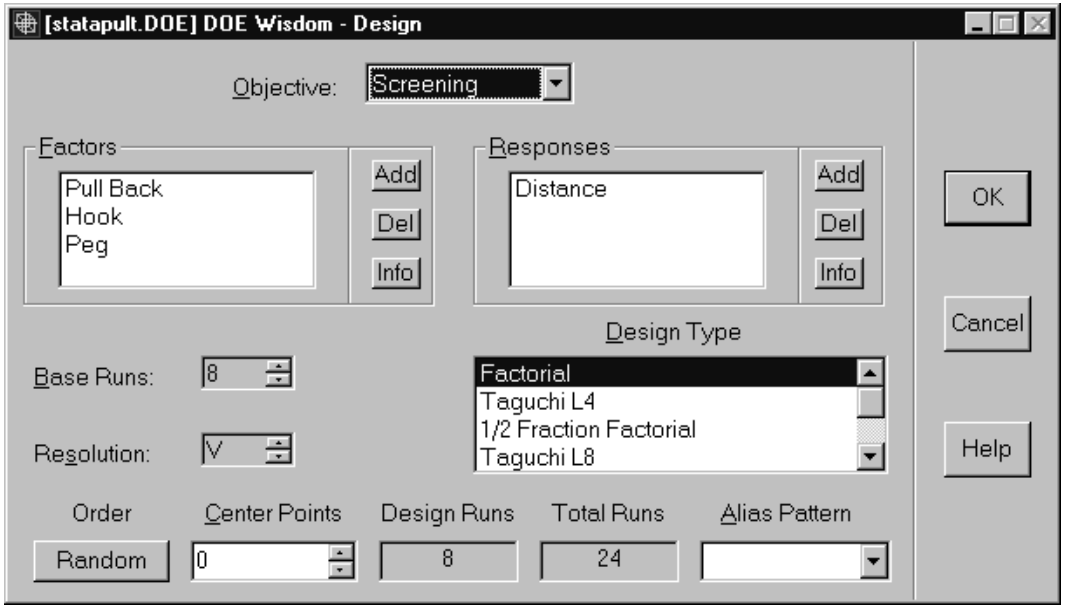


Figure 8-10

Design Type

For our example, we will use a **Taguchi L8** design. Position the mouse pointer over **Taguchi L8** and click. That design will now be highlighted.

Base Runs/Resolution/Total Runs/Centerpoints

Since a Taguchi L8 design will be used, the following will apply:

Base Runs	8
Resolution	V
Total Runs	24
Center points	0

Order
DOE Wisdom recommends standard order for a Taguchi L8 design.

Accepting the Defined Design
Once the factors, responses, design type, order and number of center points have been defined, simply choose **OK** on the Design Definition Screen.

Generating a Worksheet
Go to the **Project** window shown in Figure 8-2. Double-click on the **Worksheet** folder or click the **Worksheet** button. Select **Replicates as (Columns)** from the **View** pull-down menu. Select **Options** from the **View** pull-down menu and choose not to display the trailing zeros. Select **Font** from the **Preferences** pull-down menu and change the font to Arial, regular, 10. A worksheet is now generated for the Taguchi L8 design with three replicates. Figure 8-11 shows the worksheet for our statapult example

.

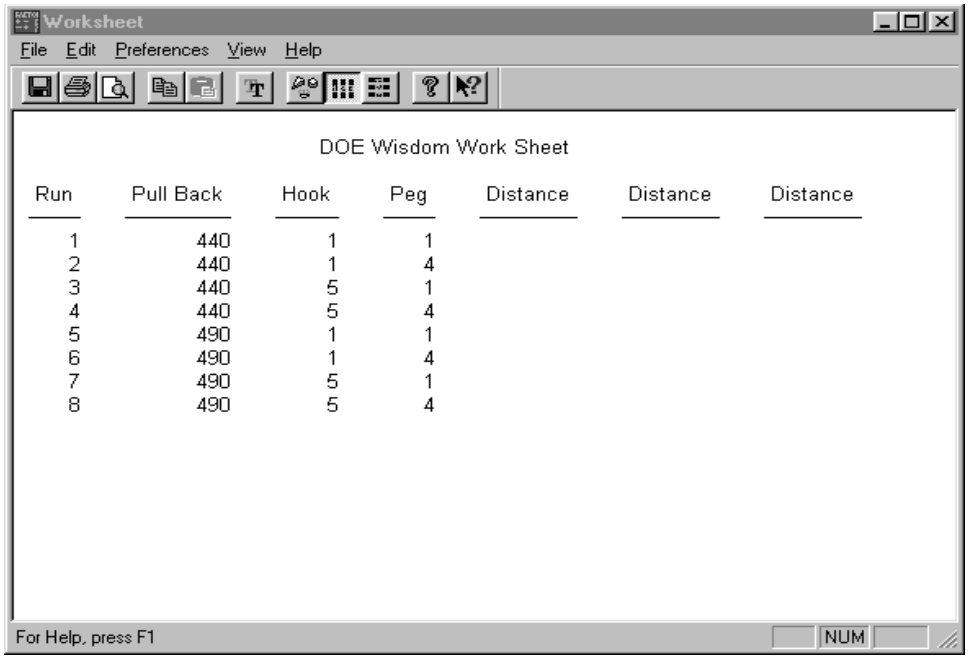


Figure 8-11

If you wish to print the worksheet, select **Print** from the worksheet **File** pull-down menu. To exit, select **Exit** from the **File** pull-down menu.

Data Definition Window

Go to the **Project** window shown in Figure 8-2. Double-click on the **Data** folder or click the **Data** button. Select **Replicates as (Columns)** from the **View** pull-down menu. A Data window similar to the one shown below will appear.

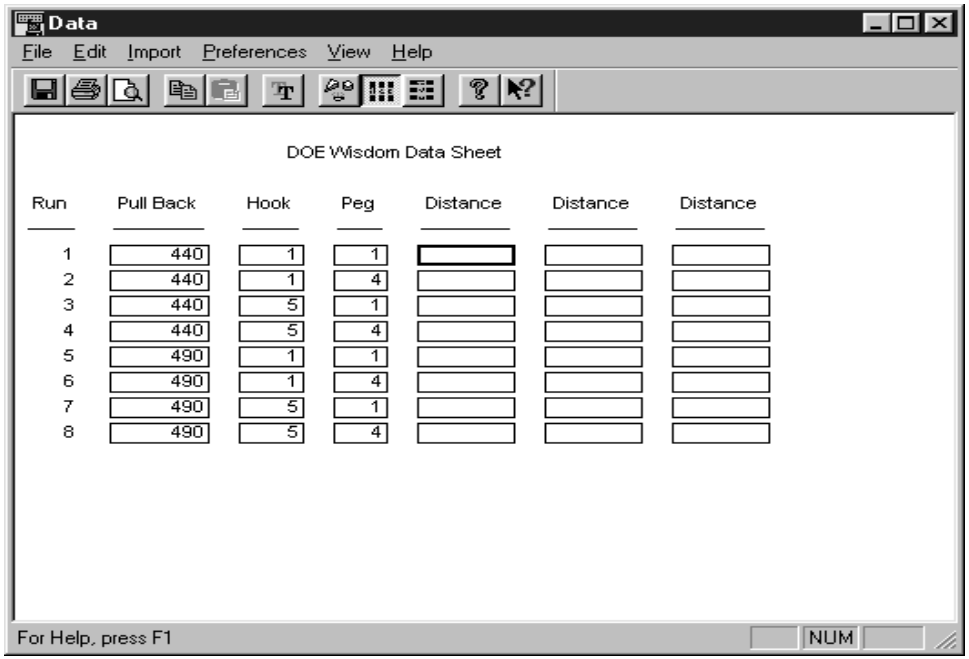
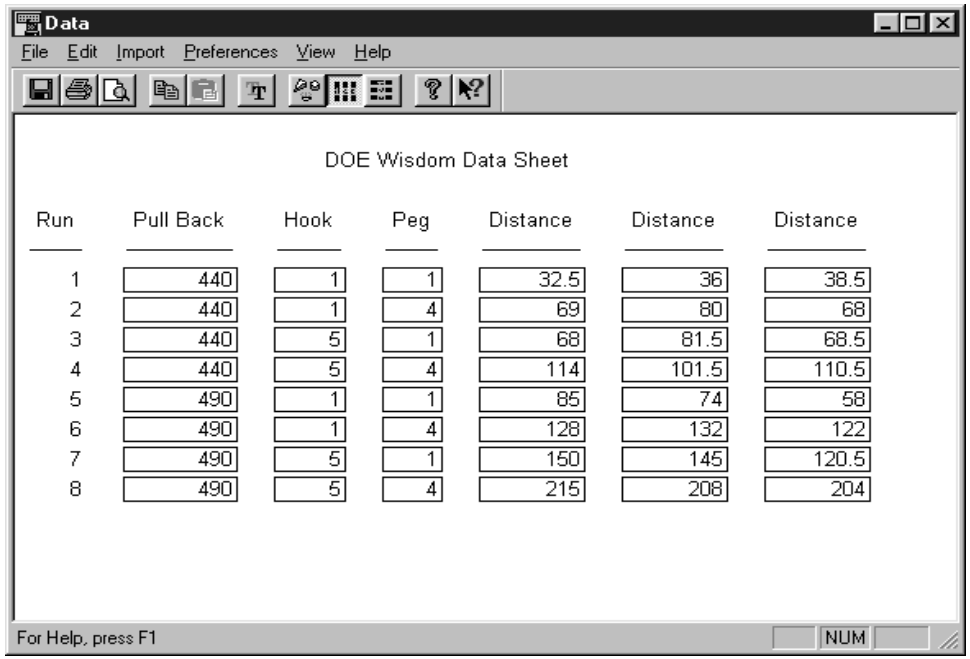


Figure 8-12

The data entry box for the first run will be bolded and the insertion point will appear in that box. Type in the response value for that run. In this case, the response value is **32.5**. Press the **Enter** key on your computer keyboard to move the insertion point to the next cell.

The numeric keypad may be used to enter data. Continue entering data so that the data sheet appears as shown in Figure 8-13.



Run	Pull Back	Hook	Peg	Distance	Distance	Distance
1	440	1	1	32.5	36	38.5
2	440	1	4	69	80	68
3	440	5	1	68	81.5	68.5
4	440	5	4	114	101.5	110.5
5	490	1	1	85	74	58
6	490	1	4	128	132	122
7	490	5	1	150	145	120.5
8	490	5	4	215	208	204

Figure 8-13

If you make a mistake while entering data, you can correct it by using one of the following methods:

- Press Backspace to delete the character to the left of the insertion point.
- Press Del to delete the character to the right of the insertion point.

Select **Save** from the **File** pull-down menu. If you want to print the data sheet, select **Print** from the **File** pull-down menu. To exit, select **Exit** from the **File** pull-down menu.

Statistics

Go to the **Project** window shown in Figure 8-2. Double-click on the **Statistics** folder or click the **Statistics** button. The Statistics window for Analysis of Means shown in Figure 8-14 will appear.

Analysis of Means

DOE Wisdom Analysis of Means

										Distance	
		Pull Back	Hook	-AB	Peg	-AC	-BC	ABC	Avg	S	ln S
		-	-	-	-	-	-	-	35.6667	3.01386	1.10322
		-	-	-	+	+	+	+	72.3333	6.65833	1.89587
		-	+	+	-	-	+	+	72.6667	7.65398	2.03523
		-	+	+	+	+	-	-	108.667	6.44851	1.86385
		+	-	+	-	+	-	+	72.3333	13.5769	2.60837
		+	-	+	+	-	+	-	127.333	5.03322	1.61606
		+	+	-	-	+	+	-	138.500	15.7877	2.75923
		+	+	-	+	-	-	+	209.000	5.56776	1.71699
									104.563	7.96753	1.94985
Avg	Avg-	72.3333	76.9167	113.875	79.7917	111.167	106.417	102.542			
	Avg+	136.792	132.208	95.2500	129.333	97.9583	102.708	106.583			
	Delta	64.4583	55.2917	-18.6250	49.5417	-13.2083	-3.70833	4.04167			
	Delta/2	32.2292	27.6458	-9.31250	24.7708	-6.60417	-1.85417	2.02083			
S	Avg-	5.94367	7.07059	7.75690	10.0081	5.31720	7.15177	7.57081			
	Avg+	9.99140	8.86448	8.17816	5.92696	10.6179	8.78329	8.36425			
	Delta	4.04773	1.79389	0.421263	-4.08115	5.30065	1.63153	0.793440			
	Delta/2	2.02386	0.896945	0.210631	-2.04057	2.65033	0.815763	0.396720			
ln S	Avg-	1.72454	1.80588	1.86883	2.12651	1.61787	1.82311	1.83559			
	Avg+	2.17516	2.09382	2.03088	1.77319	2.28183	2.07660	2.06411			
	Delta	0.450623	0.287944	0.162049	-0.353319	0.663955	0.253486	0.228525			
	Delta/2	0.225311	0.143972	0.0810247	-0.176659	0.331977	0.126743	0.114263			

Figure 8-14

In Figure 8-14, all the statistics for the interactions appear. Select the **Report Variables** option from the **Edit** pull-down menu or click the **Edit Variables** button. A window similar to the one shown in Figure 8-15 will appear.

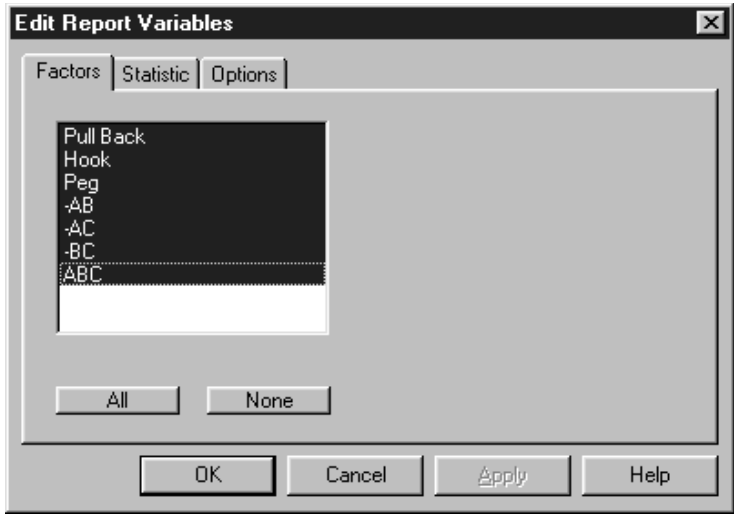


Figure 8-15

Click the **Factors** tab to display factors that can be added or removed. Highlighted factors will remain in the ANOM. Currently all factors and interactions are in the ANOM. Position the mouse pointer over the ABC interaction and click. The interaction will no longer be highlighted. Position the mouse pointer over the -BC interaction and click. Position the mouse pointer over the -AC interaction and click. Position the mouse pointer over the -AB interaction and click. The only items that should now be highlighted are Pull Back, Hook and Peg. Choose **OK** and the ANOM will now appear with only Pull Back, Hook and Peg displayed as shown in Figure 8-16.

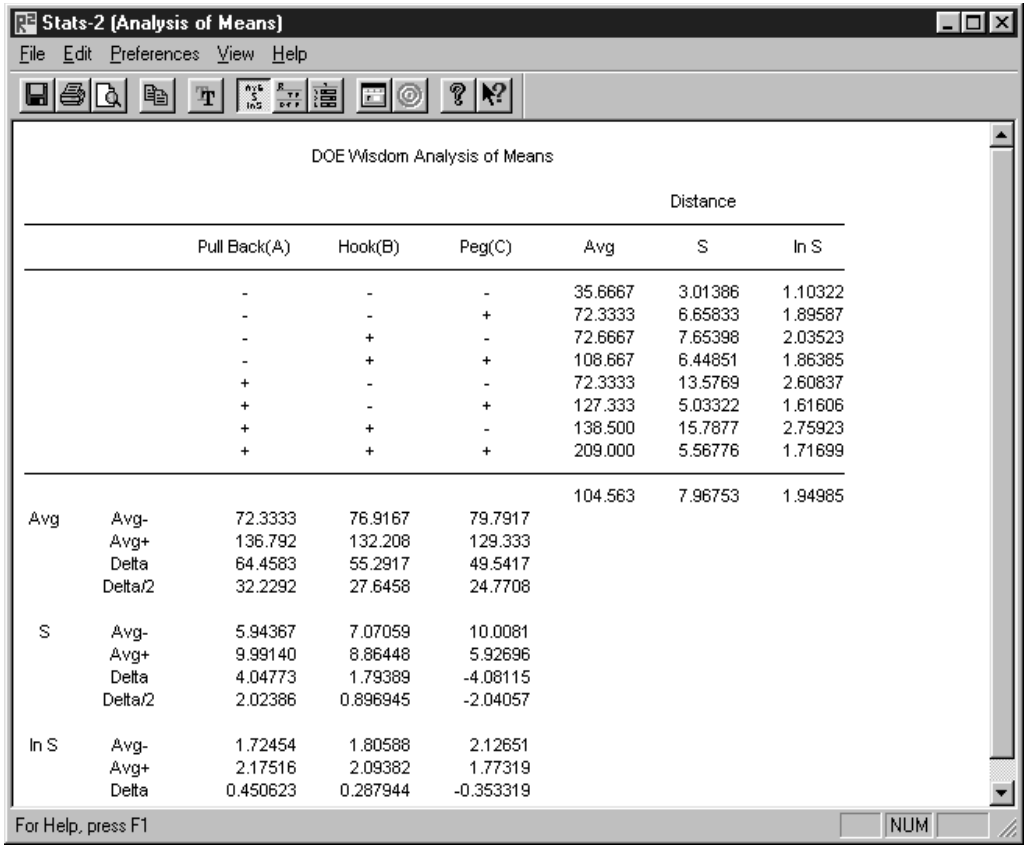


Figure 8-16

Taguchi Signal-To-Noise Statistics

Since our example is a Taguchi design, the various S/N ratios can be displayed in the ANOM. Select the **Report Variables** option from the **Edit** pull-down menu or click the **Edit Variables** button. The tab window shown in Figure 8-15 will appear. Click on the **Statistic** tab to display the various statistics that can be displayed in the ANOM.

DOE Wisdom supports the following S/N ratios:

Smaller is better
Larger is better
Nominal is better

Use the mouse pointer to select a S/N ratio. Click the left mouse button to highlight the desired S/N ratio. Choose **OK**. The ANOM will now appear with the statistics for the selected S/N ratio displayed.

Analysis of Variance

You can select the ANOVA by clicking on the **ANOVA** button or by selecting **Analysis of Variance** from the **View** pull-down menu. When Analysis of Variance is selected, a screen similar to the one shown in Figure 8-17 will appear.

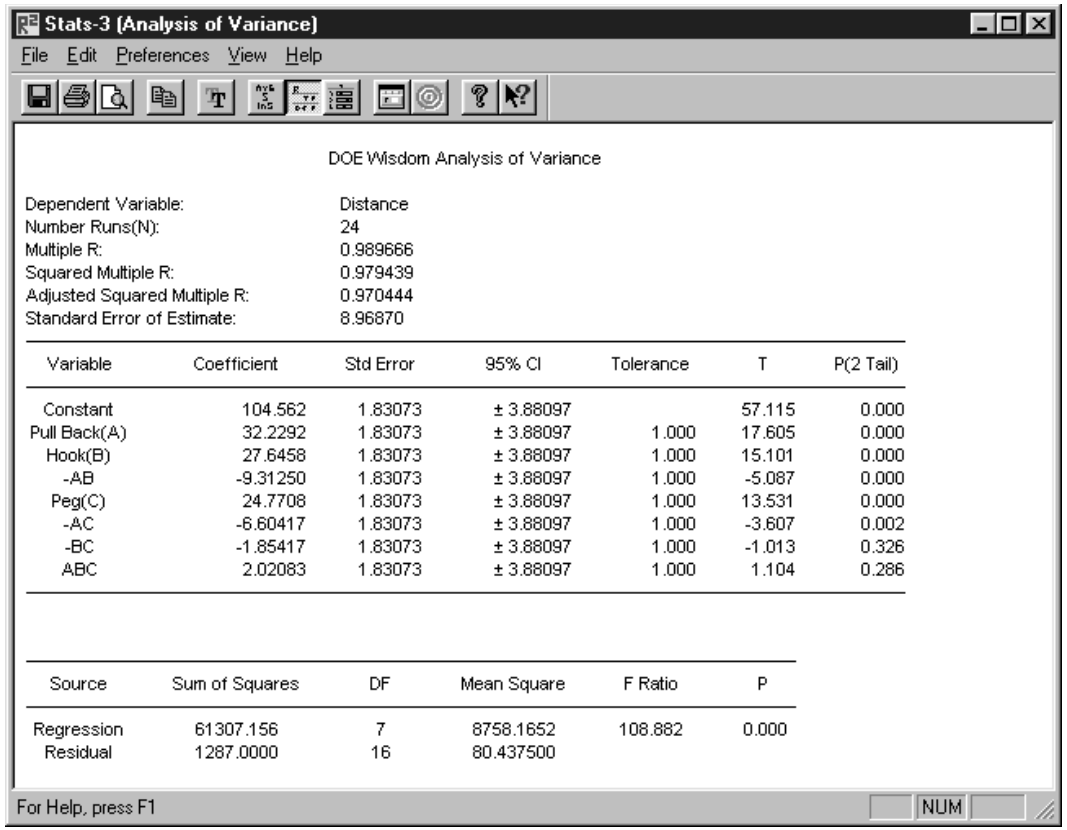


Figure 8-17

Select the **Report Variables** option from the **Edit** pull-down menu. A window similar to the one shown in Figure 8-18 will appear.

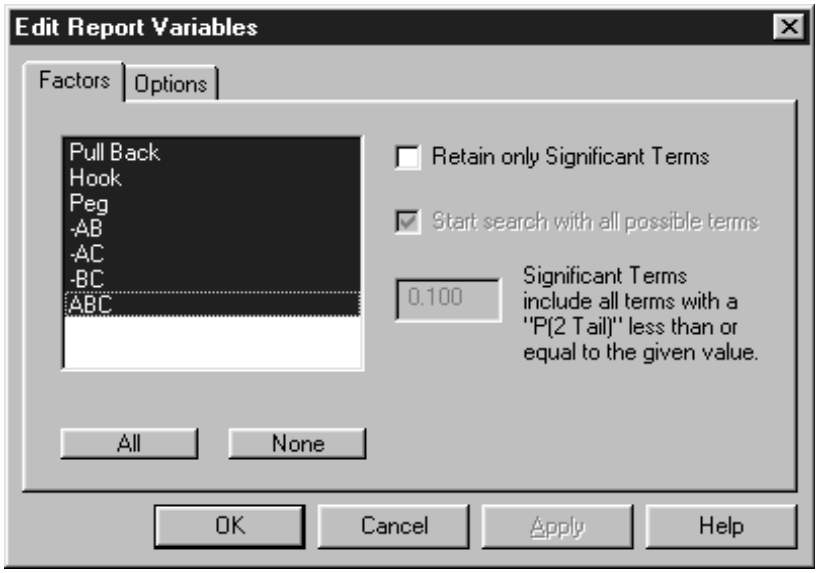


Figure 8-18

Select **Retain only Significant Terms**. A checkmark should now appear in the box. Click on **OK** at the bottom of the window. The ANOVA will now be displayed for only the significant terms. Select **Save** from the **File** pull-down menu to save the modified ANOVA.

Prediction Equation

You can select the Prediction Equation by clicking on the **Prediction Equation** button or by selecting **Prediction Equation** from the **View** pull-down menu. When Prediction Equation is selected, a screen similar to the one shown in Figure 8-19 will appear.

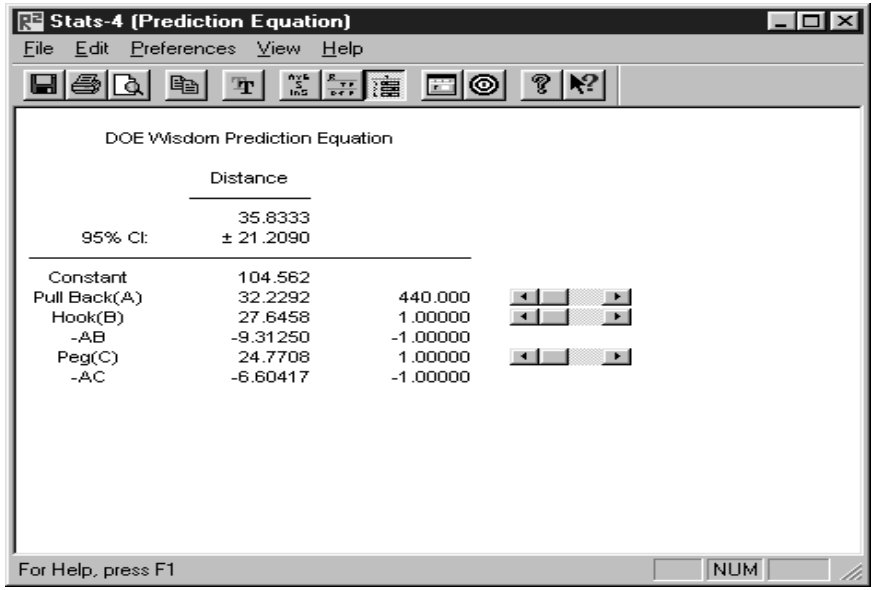


Figure 8-19

The horizontal scroll bars to the right of each factor can be used to change the factor settings and observe the new predicted response value. Change the settings as follows:

Pull Back	490
Hook	5
Peg	4

The new predicted "Distance" value is 205.125. Figure 8-20 shows the modified screen.

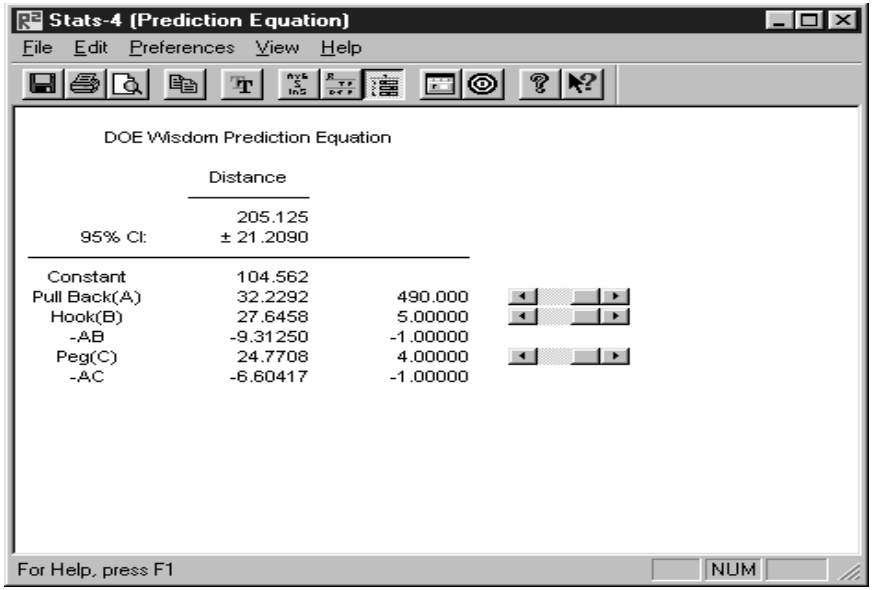


Figure 8-20

Hitting a Target

When the prediction equation screen is selected, the target button will become active. Click on the **Target** button or select **Find a Target** from the **Edit** pull-down menu. The screen shown in Figure 8-21 will appear.

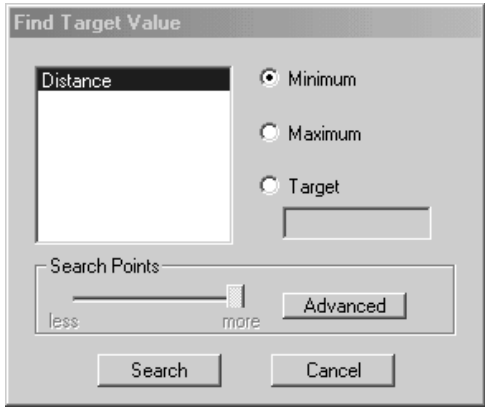


Figure 8-21

In this example, "Distance" is the response. We want to hit a target value of 200. Select **Target** and type in the value of **200**. The screen will now appear as shown in Figure 8-22.

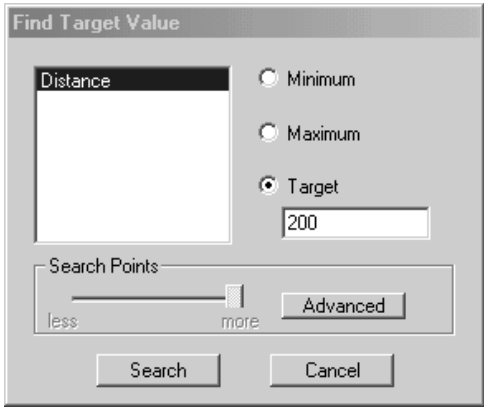


Figure 8-22

Click on the **OK** button. The software will now recommend factor settings that will "hit this target." A screen similar to the one shown in Figure 8-23 will appear.

In this example, the software shows that a distance of 199.347 can be "hit" by setting"

Pull Back	487
Hook	5
Peg	4

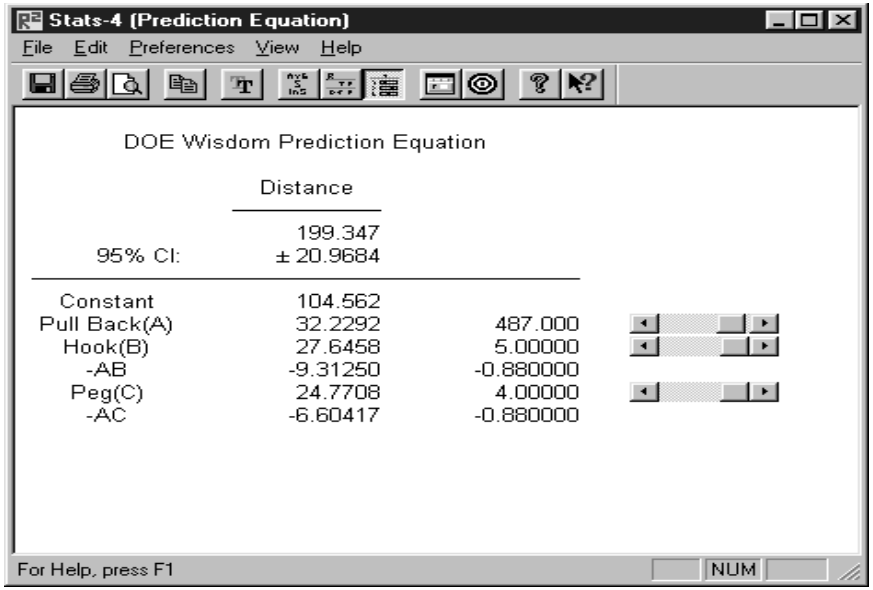


Figure 8-23

If you want to print any of the statistics sheets, select **Print** from the **File** pull-down menu. To exit, select **Exit** from the **File** pull-down menu.

Graphics

Go to the **Project** window shown in Figure 8-2. Double-click on the **Graphics** folder or click the **Graphics** button. The Graphics window for Pareto Chart shown in Figure 8-24 will appear.

Pareto Chart

You can select the Pareto Chart by clicking on the **Pareto Chart** button or by selecting **Pareto Chart** from the **View** pull-down menu. Figure 8-24 shows the Pareto Chart for our statapult example.

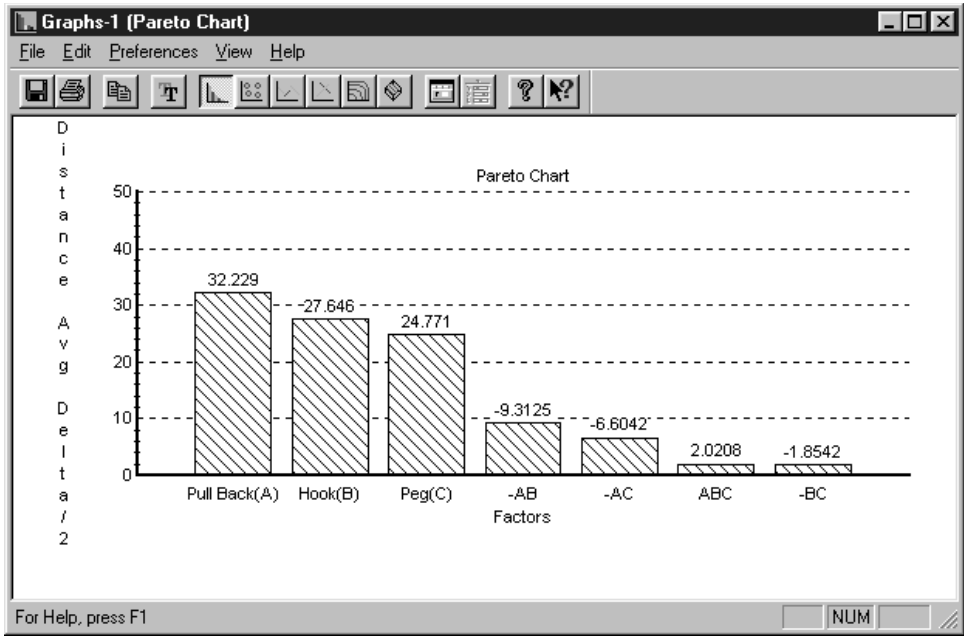


Figure 8-24

Scatter Plot

You can select the Scatter Plot by clicking on the **Scatter Plot** button or by selecting **Scatter Plot** from the **View** pull-down menu. The plot shown in Figure 8-25 will appear.

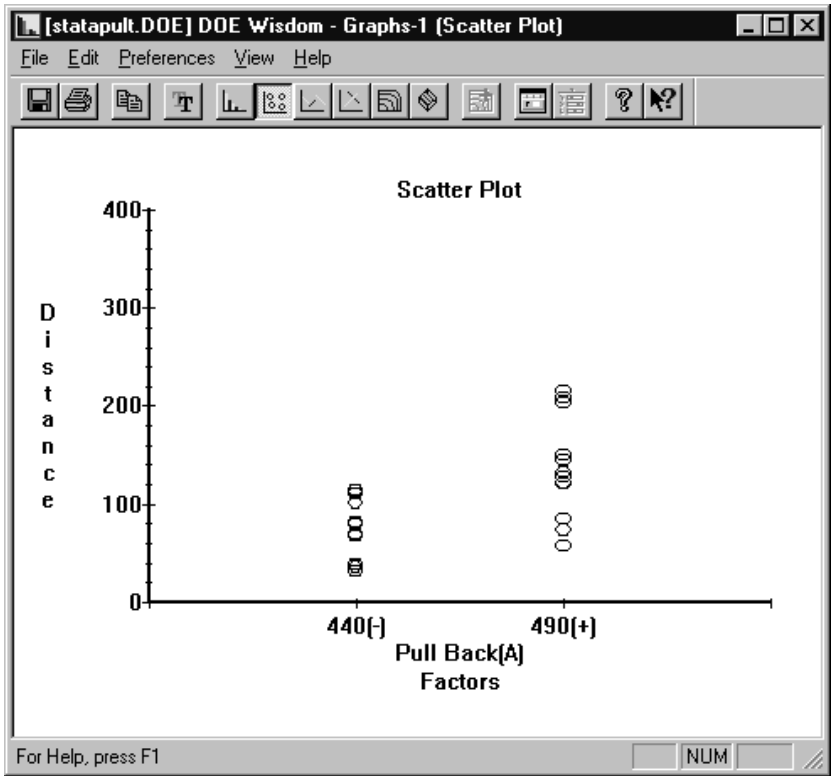


Figure 8-25

To display the Scatter Plot for all factors, select the **Graph** option from the **Edit** pull-down menu or click the **Edit Graph** button. A window similar to the one shown in Figure 8-26 will appear.

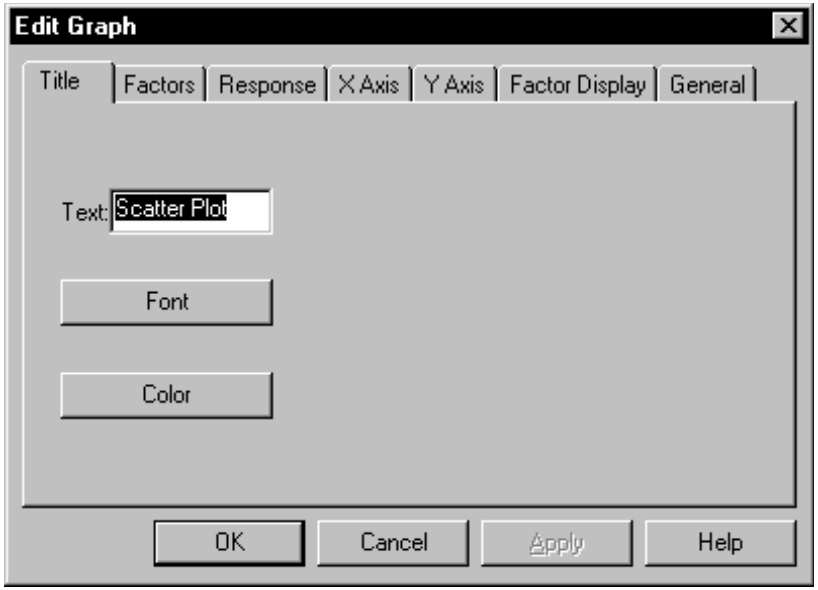


Figure 8-26

Click the **Factors** tab to display the factors that can be added or removed from the Scatter Plot. A screen similar to the one shown in Figure 8-27 will appear.

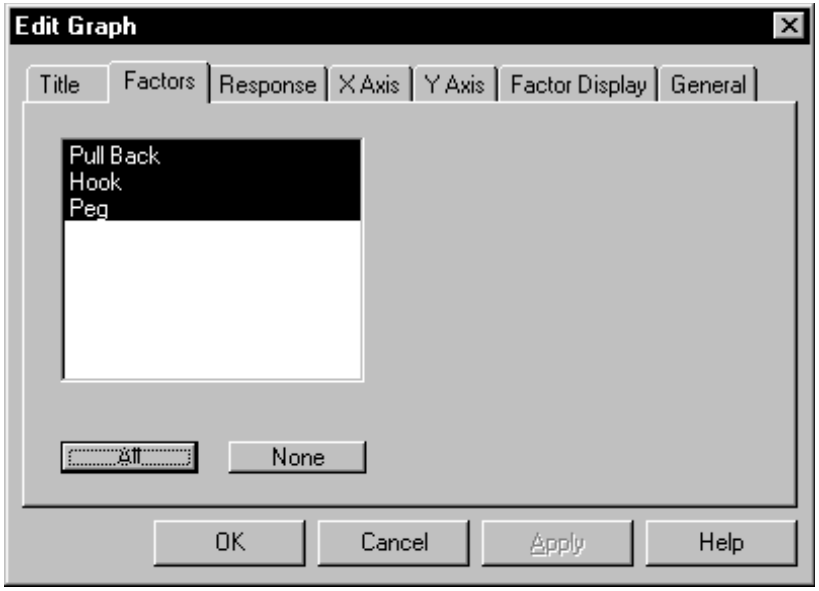


Figure 8-27

Click on the **All** button. All factors will now be highlighted and will be included in the new Scatter Plot. Click on **OK**. The Scatter Plot shown in Figure 8-28 will now appear.

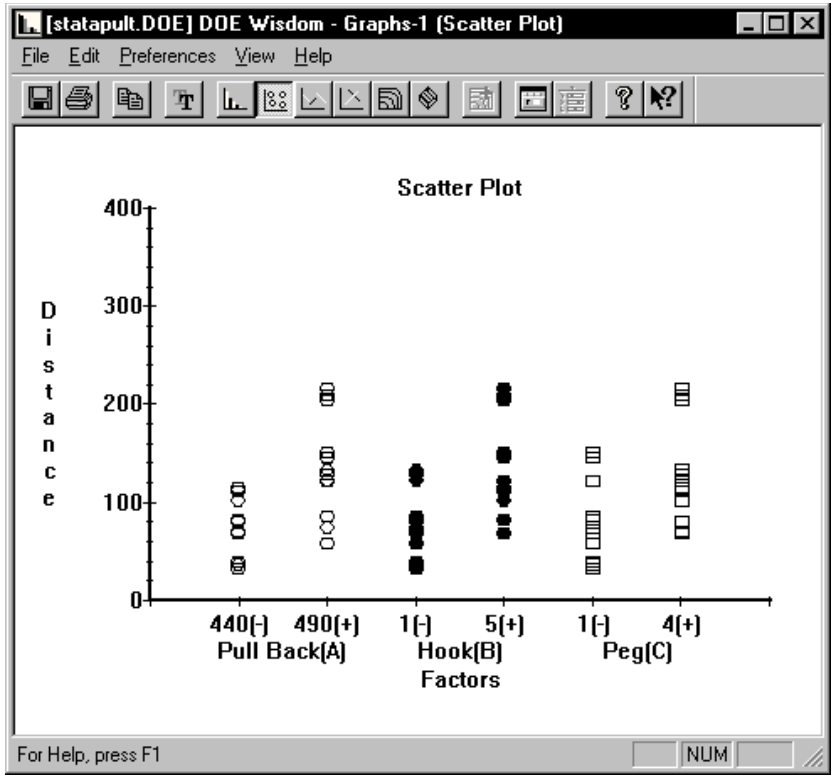

[statapult.DOE] DOE Wisdom - Graphs-1 (Scatter Plot)
File Edit Preferences View Help
Scatter Plot
Distance
400
300
200
100
0
440(-) 490(+) 1(-) 5(+) 1(-) 4(+)
Pull Back(A) Hook(B) Peg(C)
Factors
For Help, press F1
NUM

Figure 8-28

Main Effects

You can select the Main Effect Plot by clicking the **Main Effects Plot** button or by selecting **Main Effects** from the **View** pull-down menu. A graph similar to the one shown in Figure 8-29 will appear.

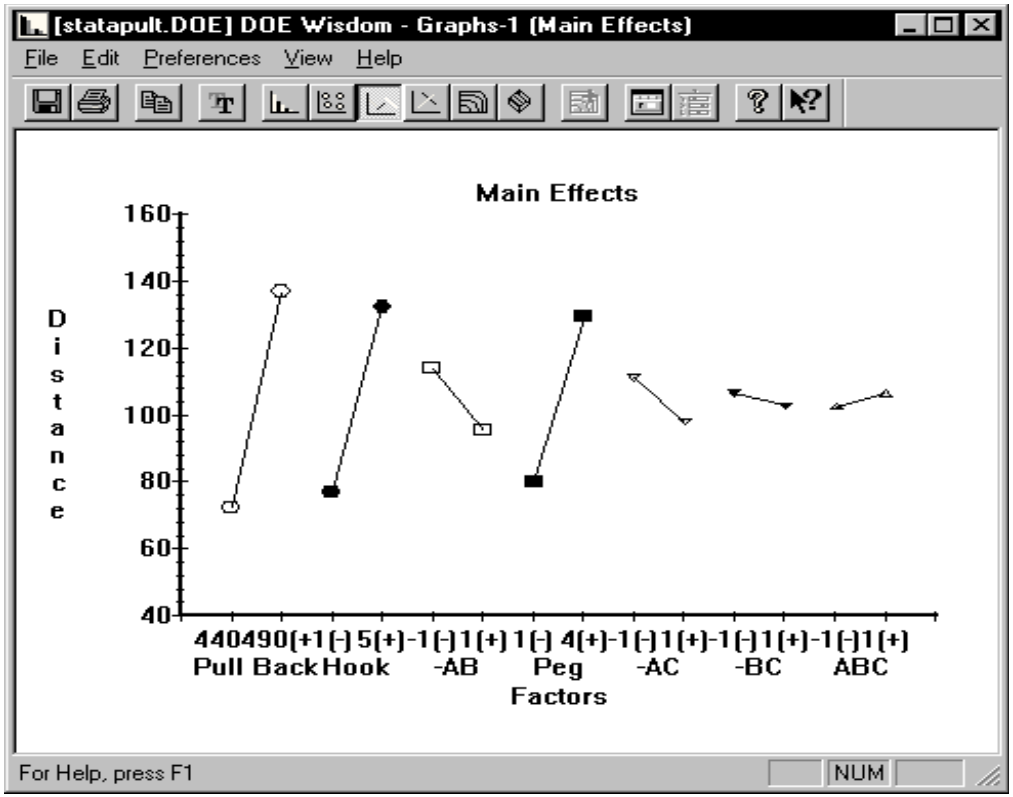


Figure 8-29

Interactions

You can select the Interactions Plot by clicking the **Interactions** button or by selecting **Interactions** from the **View** pull-down menu. A graph similar to the one shown in Figure 8-30 will appear.

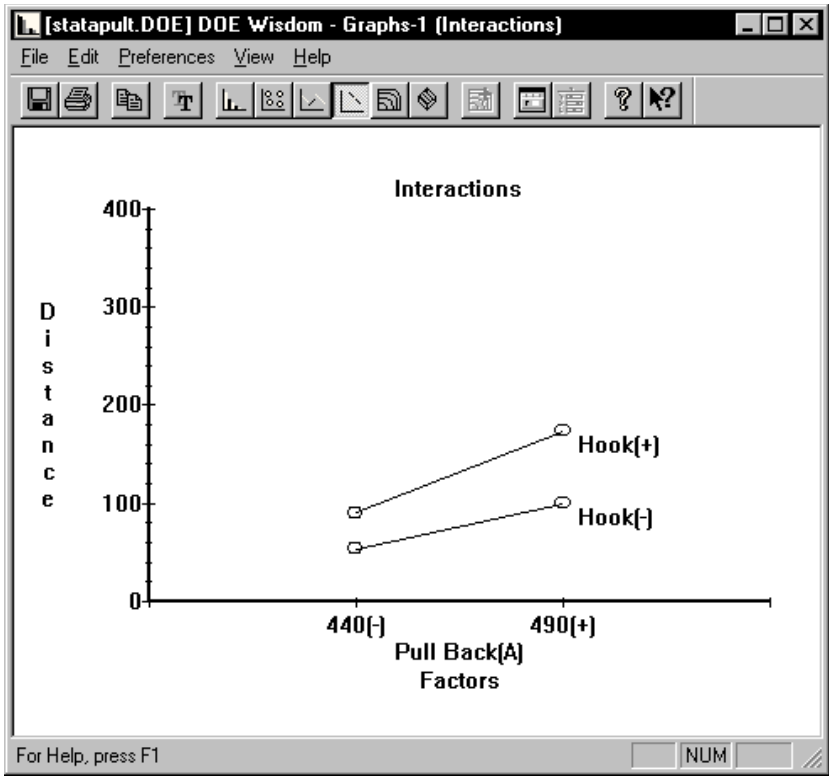


Figure 8-30

Contour Plot

You can select the Contour Plot by clicking the **Contour Plot** button or by selecting **Contour Plot** from the **View** pull-down menu. A graph similar to the one shown in Figure 8-31 will appear.

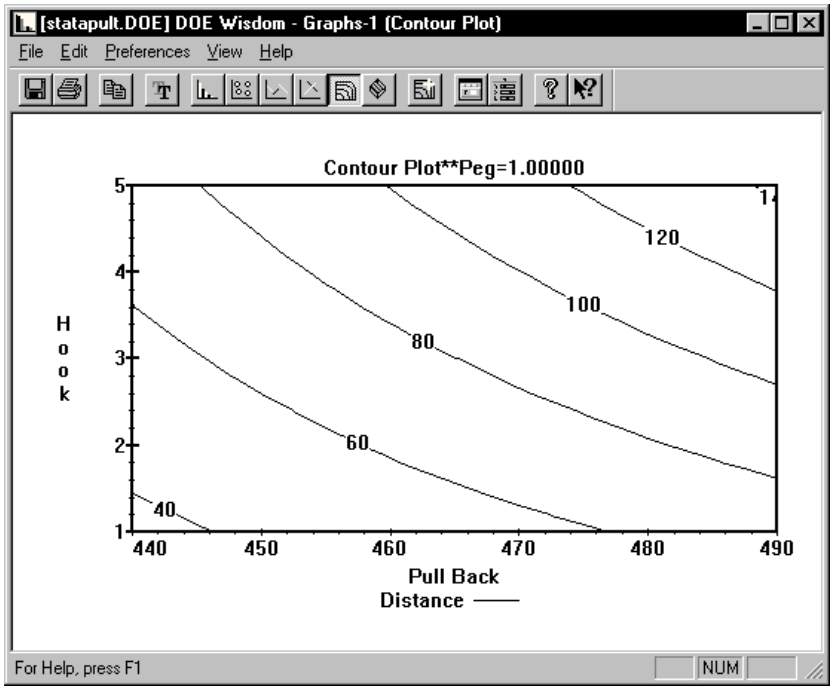


Figure 8-31

Response Surface Plot

You can select the Response Surface Plot by clicking the **Response Surface** button or by selecting **Response Surface** from the **View** pull-down menu. A graph similar to the one shown in Figure 8-32 will appear.

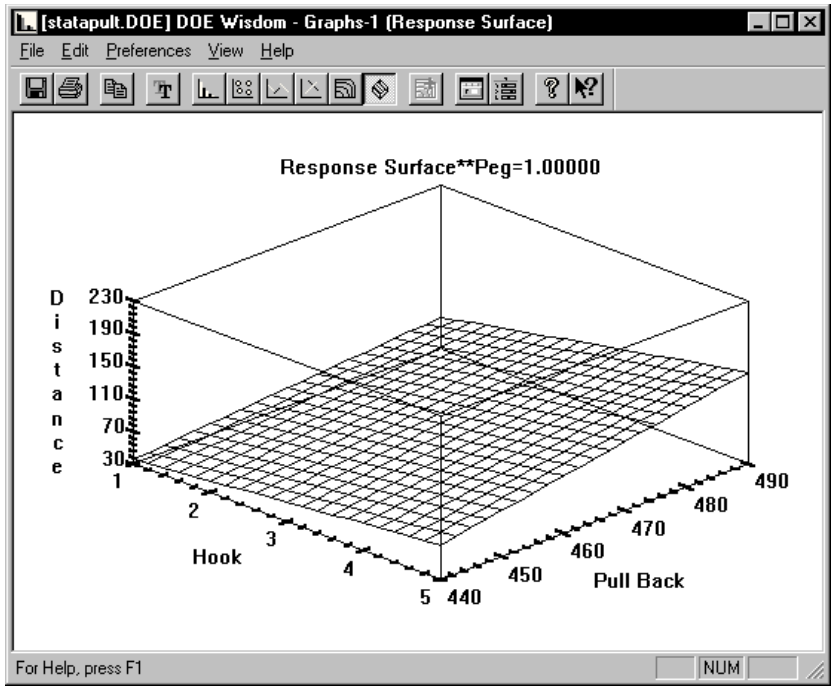


Figure 8-32

Residual Histogram

You can select the Residual Histogram by clicking the **Residual Histogram** button or by selecting **Residual Histogram** from the **View** pull-down menu. A graph similar to the one shown in Figure 8-33 will appear.

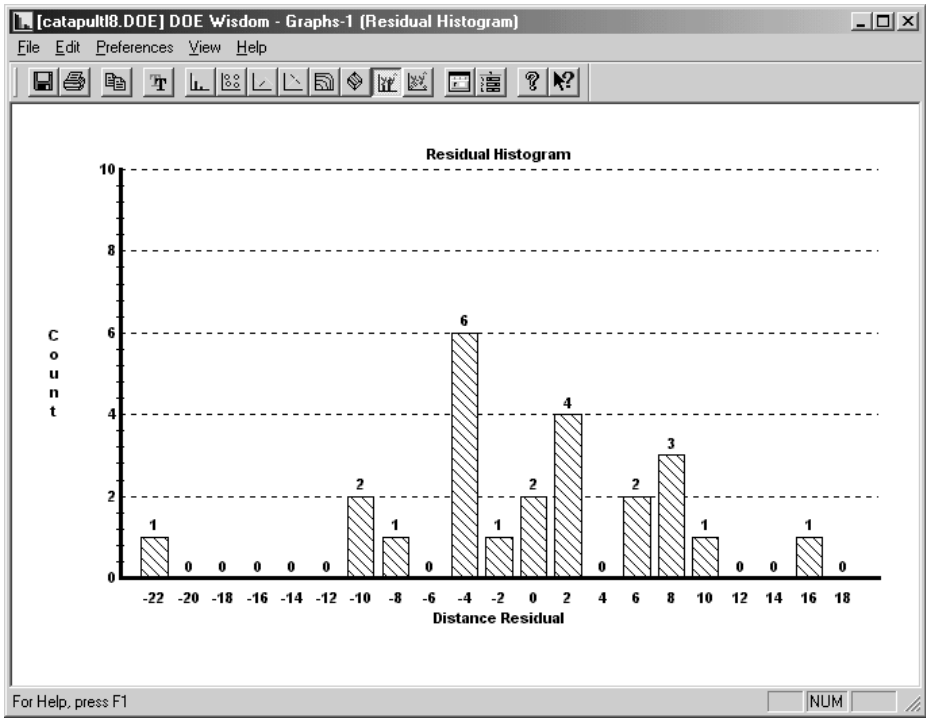


Figure 8-33

Residual Scatter Plot

You can select the Residual Scatter Plot by clicking the **Residual Scatter Plot** button or by selecting **Residual Scatter Plot** from the **View** pull-down menu. A graph similar to the one shown in Figure 8-34 will appear.

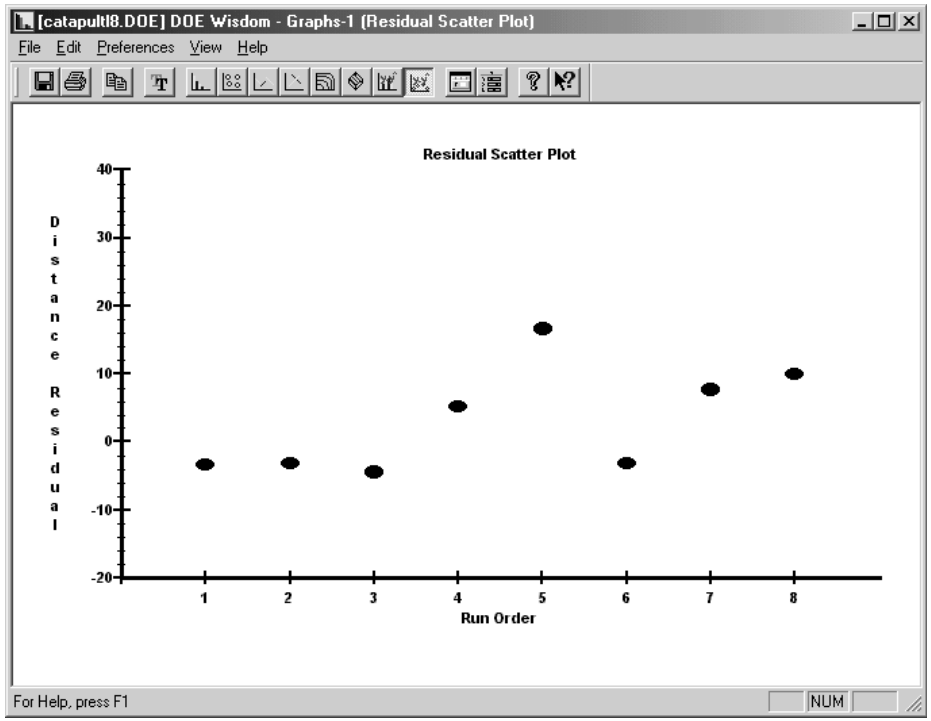


Figure 8-34

When you are finished displaying all the graphics, select **Exit** from the **File** pull-down menu.

You are now ready to create your own experiment!