

# DOE Perspectives

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## Experiment Strategies

### The Fine Art of Blocking

Have you ever wanted to divide your experimental trials between two different machines to save time? Were you concerned that differences in the two machines could contaminate your data? Did it seem to you that

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there must be a way to split the trials between two machines without serious consequences? Well, you were right — you can split your runs and avoid the consequences of contamination using a technique called “blocking.”

#### **Blocking**

“Blocking” means to divide your trials into

“blocks.” The trials in each block are carefully chosen to avoid the potentially detrimental effects of contamination. After dividing your trials into two blocks, you run one block on your first machine and the other on your second machine. You analyze the experiment as though you had used only one machine. The differences in the two machines will cancel out mathematically during the analysis.

So how do you choose the trials for each block? The procedure turns out to be very simple.

#### **Three Steps to Blocking**

First you need a design design coded in the -1 to 1 scale. You can find this in a table of experiment designs or get it from your software. (Please see Table 1 for an example.) Your design will need to be capable of analyzing for interactions of three or more factors.

Second, create a column called “block.” In this column you will write

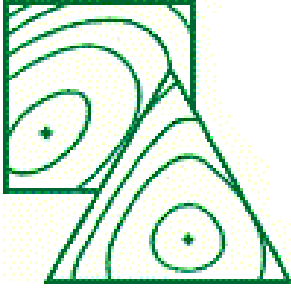


the product of the factors for that run. For example, run 1 in Table 1 is -1, -1, -1, -1. The number in the block column will be  $-1 * -1 * -1 * -1 = 1$ . Table 2 has the block column completed for the design in table 1. Whenever you see a -1 in the block column, run the trial in machine 1. Whenever you see a 1 in the block column, run the trial in machine 2.

Third, analyze the experiment as though the block column had never existed. The block column was only needed to assign the trials to blocks. The differences in the two machines will automatically cancel out during the anal-

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# The Fine Art of Blocking



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ysis.

### How Does it Work?

So how does this magic work? The “block” column is really a column which could be used to analyze the effect of a high order interaction. In the example case of Tables 1 and 2, “block” is the column for the four factor interaction of X1, X2, X3, and X4. This design clearly distinguishes the four factor interaction from the main effects and other interactions. This allows it to cancel the effect of two different machines. If your four factor interaction is not important (and it often isn’t) you can use it for blocking.

### To Block, or Not To Block

Suppose you are studying ceramics which you need to bake. You would like to use two different ovens. You can use blocking to determine which trials should be

run in each oven. The samples will be removed from the oven and allowed to cool in similar conditions. Then your responses can be measured. This is an ideal situation for blocking.

Now suppose you want to use the same oven to bake all of your ceramics, but you wish to analyze half in building 1 and half in building 2. If you cool the samples under the same conditions and then move them to the different buildings, you can safely use blocking. If you move the samples to the different buildings before cooling, you should not use blocking. Changes can occur due to different cooling conditions which have nothing to do with the oven used.

### Happy Blocking!

The next time you can save time by dividing your experimental trials between two machines, don’t

hesitate to block.

### About the Author

William D. Kapele is President of Math Options Inc. Math Options provides simplified mathematics to industry, including training in DOE and RSM. Bill can be reached toll free at (888) 764-3958.

If you’d like to learn more about blocking you can read pages 336-338 in “Statistics for Experimenters,” by Box, Hunter, and Hunter. This is an excellent book for those who wish to learn more about DOE and RSM. You may find this in your company’s library. You can order a copy through the Math Options Bookstore at <http://www.mathoptions.com/bookstor.htm>. Math Options offers this bookstore in association with Amazon.com.

TRIAL	X1	X2	X3	X4
1	-1	-1	-1	-1
2	1	-1	-1	-1
3	-1	1	-1	-1
4	1	1	-1	-1
5	-1	-1	1	-1
6	1	-1	1	-1
7	-1	1	1	-1
8	1	1	1	-1
9	-1	-1	-1	1
10	1	-1	-1	1
11	-1	1	-1	1
12	1	1	-1	1
13	-1	-1	1	1
14	1	-1	1	1
15	-1	1	1	1
16	1	1	1	1

Table 1 — 4 factor factorial design

TRIAL	X1	X2	X3	X4	BLOCK
1	-1	-1	-1	-1	1
2	1	-1	-1	-1	-1
3	-1	1	-1	-1	-1
4	1	1	-1	-1	1
5	-1	-1	1	-1	-1
6	1	-1	1	-1	1
7	-1	1	1	-1	1
8	1	1	1	-1	-1
9	-1	-1	-1	1	-1
10	1	-1	-1	1	1
11	-1	1	-1	1	1
12	1	1	-1	1	-1
13	-1	-1	1	1	1
14	1	-1	1	1	-1
15	-1	1	1	1	-1
16	1	1	1	1	1

Table 2 — 4 factor factorial design with block column

# Notices

Process Builder and Math Options have teamed up to offer a free design check service. Send them your design before you collect data and they will tell you the quality of the design for free! Send them your design with data and goals and they will tell you if they can find a sweet spot. You can find out more about it at [www.mathoptions.com/free.htm](http://www.mathoptions.com/free.htm)

Process builder has just released a Windows 98 compatible version of STRATEGY. Please contact Richard Nash at (206) 364-5740 to get a copy.

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StatSoft, the maker of STATISTICA, now offers an Electronic Statistics Handbook. You can download it for free from their web site at <http://www.statsoft.com/textbook/stathome.html>. You can also use the handbook on the Web without downloading. This is a very handy reference.

Are you interested in free I-Optimal designs? You can download two free designs for discrete and process factors. They are available at <http://www.mathoptions.com/free1.htm>.

Process Builder is offering several public courses in DOE and RSM in the coming year. You can see the class schedule at <http://www.processbuilder.com/education/DOE/schedule.htm>. The class and a one year software license to STRATEGY are packaged together for a very attractive price.

Back issues of *DOE Perspectives* are available from Math Options at <http://www.mathoptions.com/doe.htm>

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