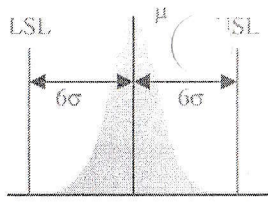


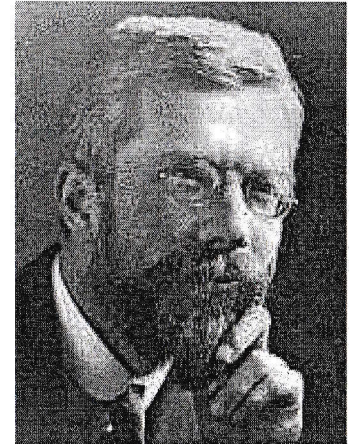
# Blocking

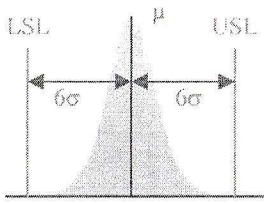
Lean Sigma  
Black Belt Training



# History of Blocking

- Concept attributed to work of Sir Ronald Fisher
  - Working to improve the yield of agricultural production
- Statistics and genetics
- Discovered differences in the output of various plots in the fields
  - Developed a methodology to statistically study differences
  - Within and Between differences
- Basic principles developed are applicable and useful to the design and execution of many area of experimentation

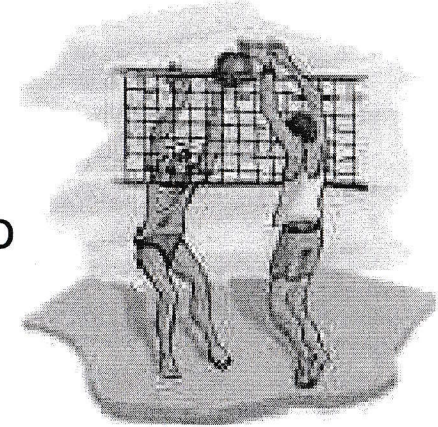




# Blocking

- **What is a Block?**

- Block - A group of experiments. Blocks are often used to better understand and evaluate "nuisance factors."

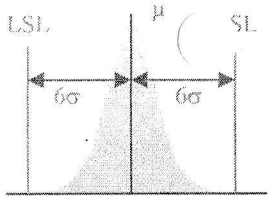


- **Why use Blocking?**

- Traditional: Make the variation in the response variable(s) due to the manipulation of the process factors more apparent by removing the variation due to the blocks.
- Process Oriented: To determine whether the effects of process factors noted in an initial experiment are repeatable across blocks. Also to see whether the overall average of the experiment changes.

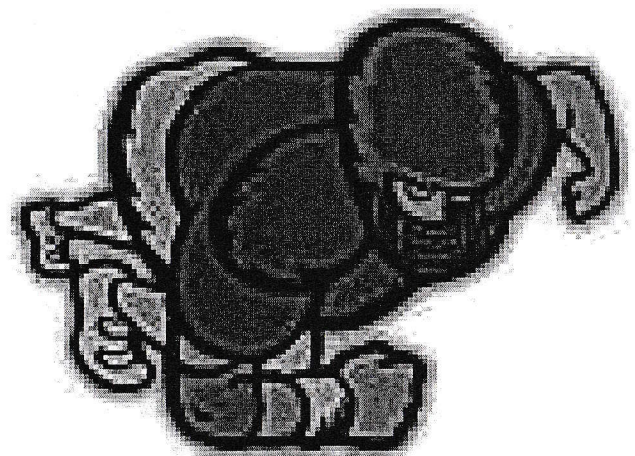




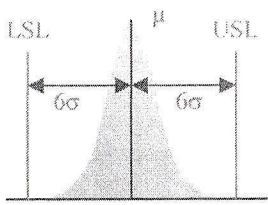


# What To Block

- Frequently a period of time where extraneous variables (X's not manipulated in the experiment) can reasonably be expected to remain constant during the experiment.
- A block could be a lot, a supplier, a machine, a shift, a batch of raw material, etc.



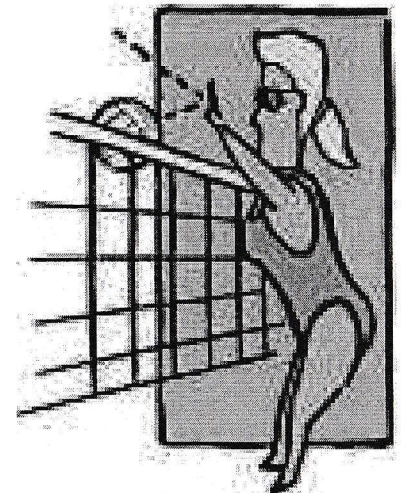


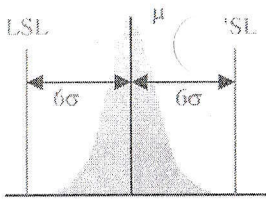


# Blocking Example

The yields of a process is considered inadequate by management. The two main factors of the process are Temperature (A) and Pressure (B).

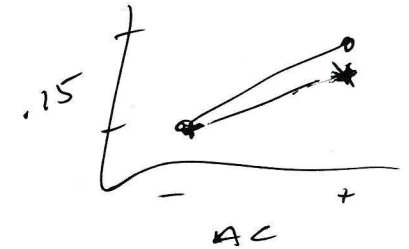
- How do we find the effects of A and C on yield?
- What are the noise factors?
- How should we treat noise factors and process factors that are not included in the design?





# Blocking Example

- Consider the following data collected from a DOE on the process



- What are the effects of A?

3.55

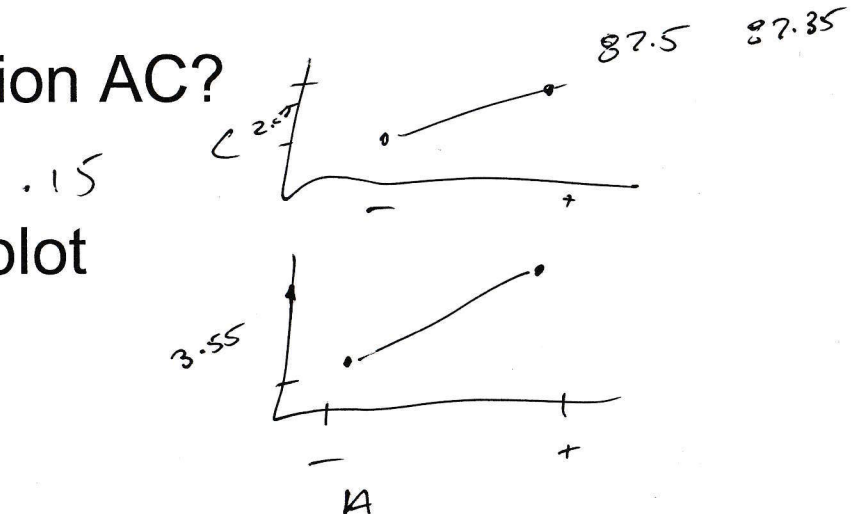
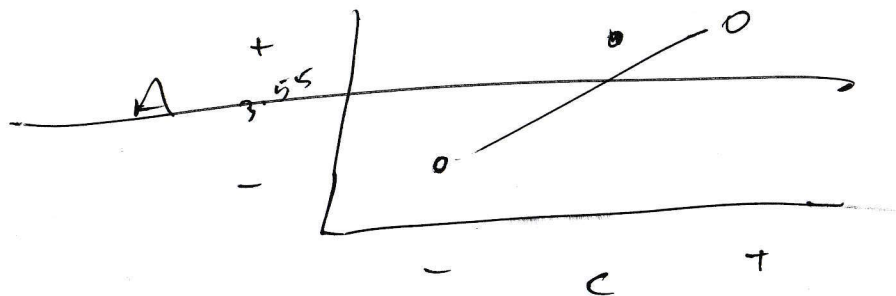
- What are the effects of C?

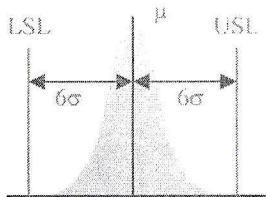
2.25

- What are the effects of the interaction AC?

- Draw and interpret the interaction plot

| A  | C  | Y     | AC |
|----|----|-------|----|
| -1 | -1 | 84.60 | +  |
| 1  | -1 | 88.00 | -  |
| -1 | 1  | 86.70 | -  |
| 1  | 1  | 90.40 | +  |





# Blocking Example

- The DOE was repeated on second shift and the following data was collected from the process

- What are the effects of A?

- What are the effects of C?

- What are the effects of the interaction AC?

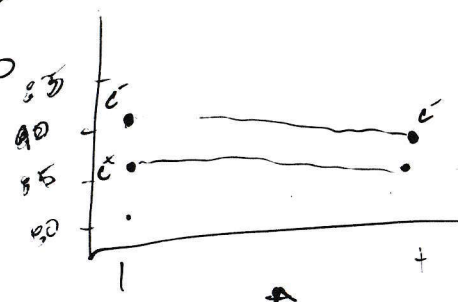
- Draw and interpret the interaction plot

- Take 20 minutes to compare your results with the results from shift one. Be prepared to answer the questions on the next page

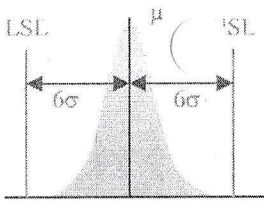
$85.55 - 83.05 = 2.5$   
 $84.8 - 83.8 = 1.0$

| A  | C  | Y     | AC |
|----|----|-------|----|
| -1 | -1 | 90.10 | +  |
| 1  | -1 | 87.50 | -  |
| -1 | 1  | 86.00 | -  |
| 1  | 1  | 83.60 | +  |

$86.85 - 86.75 = .10$

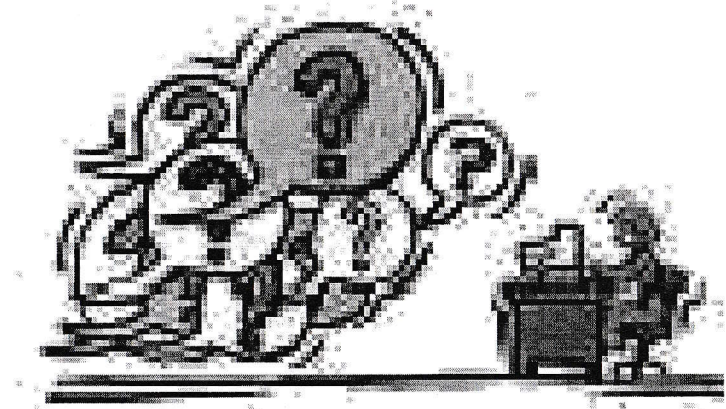


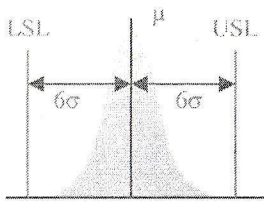




# Questions

- Why might be some of the reasons for the results to differ from one shift to another? - GAGE ARROW IN WRONG DIRECTION  
- ZEROING ISSUE DUE TO WRONG STANDARD
- How would you anticipate this situation?
- If the effects of factors included in an experiment change over time, will you be able to successfully manage the process?





# Blocking Considerations

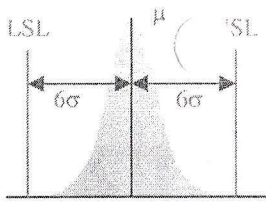
- In the previous example we may want to answer additional questions such as;
  - Are the effects of A and C consistent for each shift?
  - Are A & C truly the two most important variables to control?
  - What are other sources of variation that may exist between shifts and how consistent are they?

## **Design Strategy:**

A design that will allow us to begin to understand these questions is known as a Randomized Complete Block Design (RCBD)

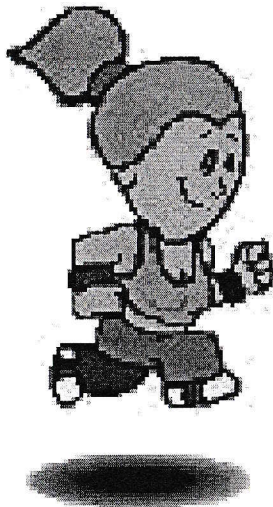
## **Analysis Strategy:**

Combine the experimental results with “Block” as a factor.



# Blocking Exercise

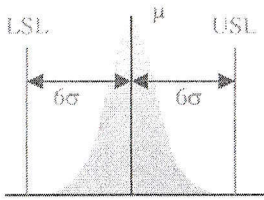
- The data from both DOE's is combined in the table below.



| $A_s$ | $A_c$ | $A_c$ | $A_c$ | $A_c$ | $A_c$ | $A_c$ |
|-------|-------|-------|-------|-------|-------|-------|
| Shift | A     | C     | Y     | AC    | ASC   |       |
| -1    | -1    | -1    | 84.60 | -     |       |       |
| -1    | 1     | -1    | 88.00 | +     |       |       |
| -1    | -1    | 1     | 86.70 | +     |       |       |
| -1    | 1     | 1     | 90.40 | -     |       |       |
| 1     | -1    | -1    | 90.10 | +     |       |       |
| 1     | 1     | -1    | 87.50 | -     |       |       |
| 1     | -1    | 1     | 86.00 | -     |       |       |
| 1     | 1     | 1     | 83.60 | +     |       |       |

- Do the analysis of the combined experiment and answer the questions on the next page. You must complete the analysis by hand. Your team has 30 minutes to complete the analysis and prepare a discussion to present to the class.
- At a minimum, your analysis should include a cube plot, interaction plots, and an effects table.

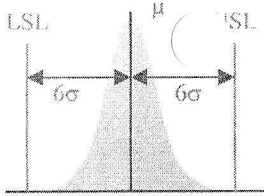




# Exercise Questions



1. Did the experimenter include all of the key process variables in the experiment? *Assuming That The Key Variables Were Identified*  
YES, BECAUSE WE DID FULL FACTORIAL BY ADDING TWO FRACTIONS
2. Did the experimenter perform the experiment across all levels of the key noise variables? *YES, CUBE IS BUILT BY INTERACTIONS*
3. What would be your recommendation as to the next step in the process investigation? *Assuming That Key Variables*  
TO UNDERSTAND WHY THE SUGGS ARE INVERTED TO EACH OTHER
4. How would you manage this process until more process knowledge is obtained? *CONTROL CHART PROCESS WHILE COLLECTING ADDITIONAL DATA*
5. When an 'identical' experiment is run at two points in time: What does a significant 'Block' effect imply? *THE PROCESS IS IMMUNE TO THE BLOCK FACTOR*
6. What does a significant 'Block'-by-factor interaction effect imply?  
 - THERE IS SOMETHING ABOUT THE NOISE IS EFFECT, PROCESS  
 - THAT WE WOULD NEED TO UNDERSTAND IN ORDER TO REMOVE THE EFFECT

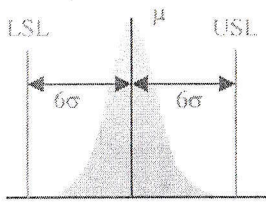


# Another Situation

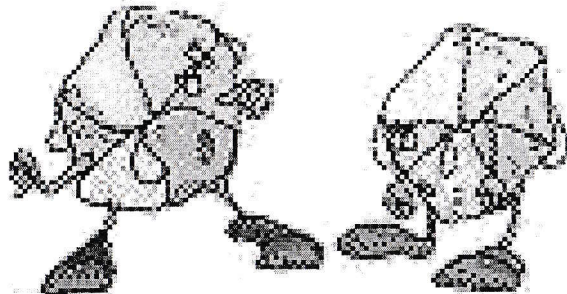
**Assignment:** Examine the data from an experiment run on a similar process at two points in time. The cube plot and factor effects are reported on the next page. Answer the questions that follow.

| Shift | A  | C  | Y     |
|-------|----|----|-------|
| -1    | -1 | -1 | 83.50 |
| -1    | 1  | -1 | 86.80 |
| -1    | -1 | 1  | 86.10 |
| -1    | 1  | 1  | 90.10 |
| 1     | -1 | -1 | 82.50 |
| 1     | 1  | -1 | 86.90 |
| 1     | -1 | 1  | 85.00 |
| 1     | 1  | 1  | 92.80 |

for  
Homework  
Week 4



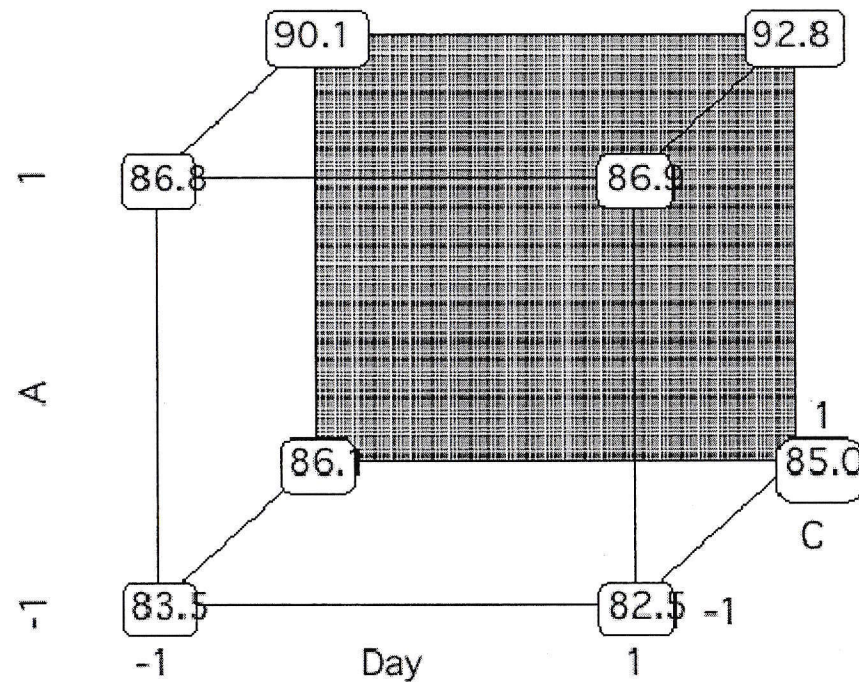
# Cube Plot



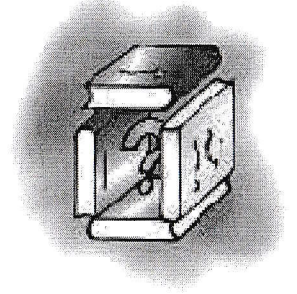
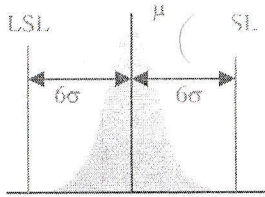
| <u>Variable</u> | <u>Effect</u> |
|-----------------|---------------|
| Day             | 0.175         |
| A               | 4.875         |
| DayA            | 1.225         |
| C               | 3.575         |
| DayC            | 0.625         |
| AC              | 1.025         |
| DayAC           | 0.675         |

Questions are on the next page

## Cube Plot

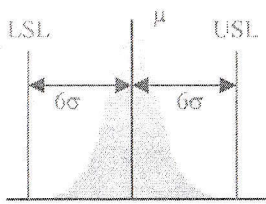






# Questions

1. Did the experimenter include all of the key process variables in the experiment?
2. Did the experimenter perform the experiment across all levels of the key noise variables?
3. What would be your recommendation as to the next step in the process investigation?
4. How would you manage this process until more process knowledge is obtained?
5. Would more complete knowledge of how 'Blocks' were selected impact your answers to the above questions?
6. Can the Block and Block-by-Factor effects be treated as 'Experimental Error'?

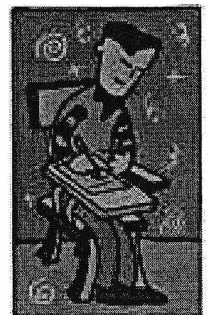


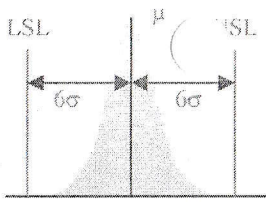
# Blocking Assignment

1. Consider noise factors or uncontrolled process factors in your processes and projects that might drift over time and invalidate the results of your process work and experimentation.
2. Develop strategies for understanding whether such factors do impact your work. Include sampling with a RCBD but be aware that RCBDs are not your only alternative.
3. Develop strategies for dealing with these factors in your processes.
4. Be prepared to discuss in Week 4 Project Reviews how you will know whether your experimental results are repeatable and sustainable?

*Homework  
Week 4*

You should begin this work tonight and be prepared to present your strategy to the class.





# Summary

- If you want to analyze the effects include as a factor “Do Not Block”
- Block to better understand uncontrollable nuisance factors
  - Shifts, Material Lots, etc