Week 13 **Chapter 4**

5.9 An article in *Industrial Quality Control* (1956, pp. 5-8) describes an experiment to investigate the effect of the type of glass and the type of phosphor on the brightness of a television tube. The response variable is the current necessary (in microamps) to obtain a specified brightness level. The data are as follows:

Glass Type	Phosphor Type		
	1	2	3
1	280	300	290
	290	310	285
	285	295	290
2	240	260	220
	235	240	225
	240	235	230

(a) Is there any indication that either factor influences brightness? Use $\alpha = 0.05$.
(b) Do the two factors interact? Use $\alpha = 0.05$.
(c) Analyze the residuals from this experiment.

Answer: By Minitab:

(a) Is there any indication that either factor influences brightness? Use $\alpha = 0.05$.

Factors are Glass Type (2 levels) and Phosphor Type (3levels).
Response is the Current necessary to obtain a specified brightness level.
Hypotheses are:

- For Glass Type (A): $H_o: \tau_1 = \tau_2 = 0$, $H_1: at\ least\ one \neq 0$
- For Phosphor Type (B): $H_o: \beta_1 = \beta_2 = \beta_3 = 0$, $H_1: at\ least\ one \neq 0$
- For Interaction (A*B): $H_o: (\tau\beta)_{ab} = 0$, $H_1: at\ least\ one \neq 0$

Confidence Level (α) = 0.05, and we will use the P-value to make conclusion depending on the rule of (If the P-value is Low the null must Go)

General Linear Model: Current uA versus Phosphorous Type, Glass Type

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Factor            Type   Levels  Values
Phosphorous Type  fixed       3  1, 2, 3
Glass Type        fixed       2  1, 2

Analysis of Variance for Current uA, using Adjusted SS for Tests

Source                        DF   Seq SS   Adj SS   Adj MS       F      P
Phosphorous Type               2    933.3    933.3    466.7    8.84  0.004
Glass Type                     1  14450.0  14450.0  14450.0  273.79  0.000
Phosphorous Type*Glass Type    2    133.3    133.3     66.7    1.26  0.318
Error                         12    633.3    633.3     52.8
Total                         17  16150.0

S = 7.26483   R-Sq = 96.08%   R-Sq(adj) = 94.44%

Unusual Observations for Current uA

Obs  Current uA      Fit  SE Fit  Residual  St Resid
 13     260.000  245.000   4.194    15.000      2.53 R

R denotes an observation with a large standardized residual.
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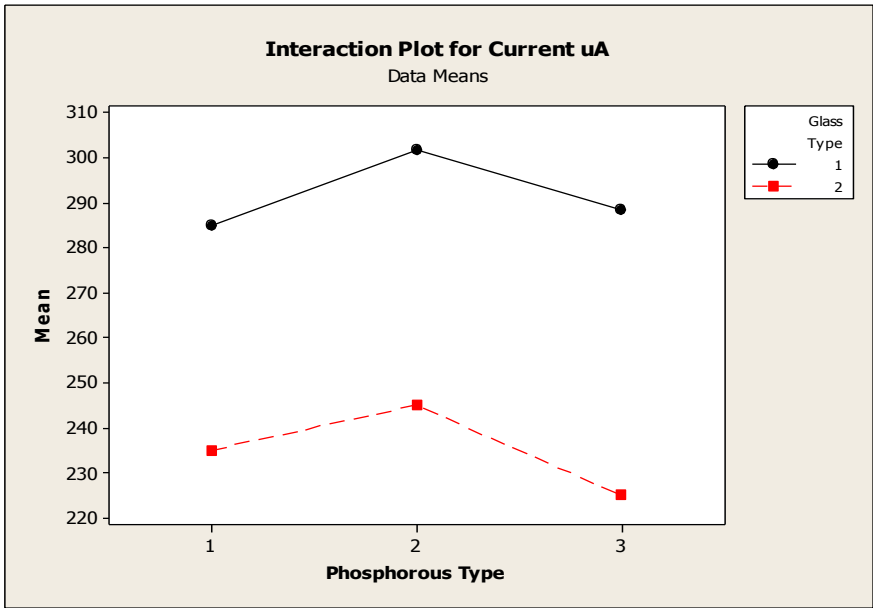
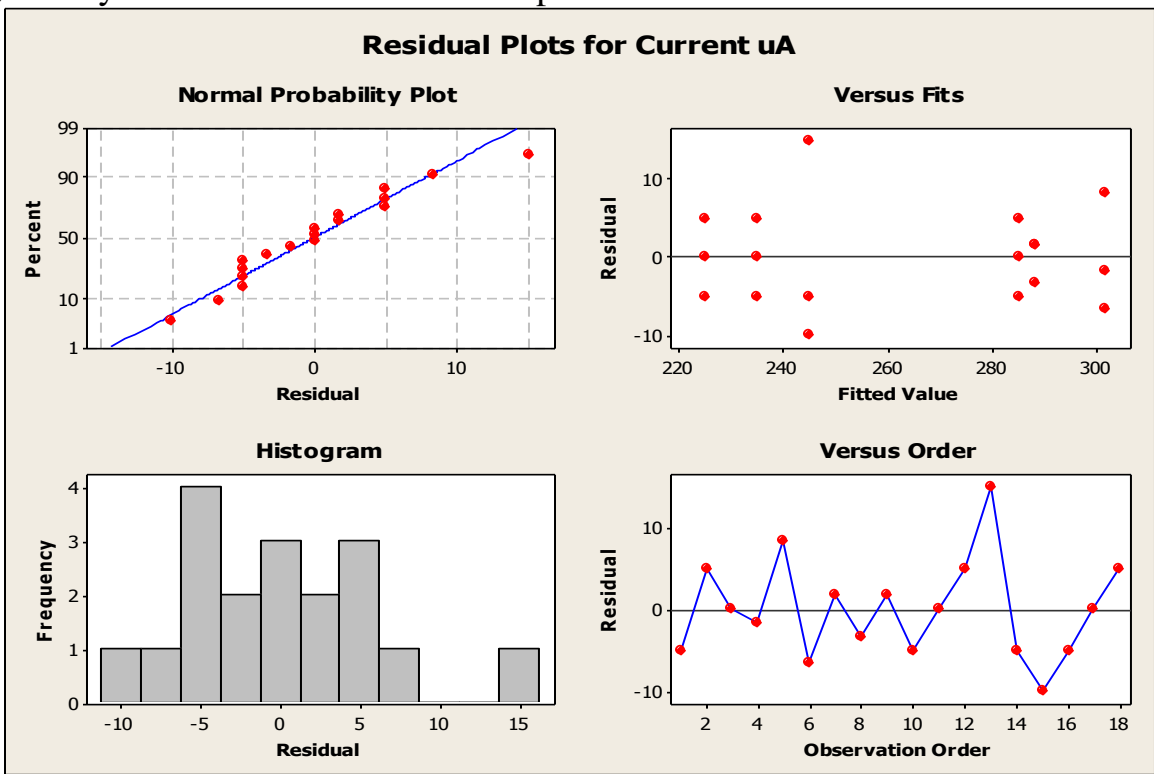
Yes, from the P-value for the two factors we can find that both factors influences brightness.

(b) Do the two factors interact? Use $\alpha = 0.05$.

No, the two factors interaction do not influence brightness.



(c) Analyze the residuals from this experiment.



Using the 4 in 1 plot from Minitab to analyze the residuals and from the plots we can verify the assumptions (The residuals are normality distributed with mean of Zero and constant variances):

From the normality plot the residuals are normality distributed, the means around zero and from the versus fits plot there is very slight inequality of variance but most of the data can be between two parallel lines and it is not serious so we accepted it.

5.12 An experiment is conducted to study the influence of operating temperature and three types of face-plate glass in the light output of an oscilloscope tube. The following data are collected:

Glass Type	Temperature		
	100	**125**	**150**
1	580	1090	1392
	568	1087	1380
	570	1085	1386
2	550	1070	1328
	530	1035	1312
	579	1000	1299
3	546	1045	867
	575	1053	904
	599	1066	889

(a) Use $\alpha = 0.05$ in the analysis. Is there a significant interaction effect? Does glass type or temperature affect the response? What conclusions can you draw?
(b) Fit an appropriate model relating light output to glass type and temperature.
(c) Analyze the residuals from this experiment. Comment on the adequacy of the models you have considered.

Answer: By Minitab:

(a) Use $\alpha = 0.05$ in the analysis. Is there a significant interaction effect? Does glass type or temperature affect the response? What conclusions can you draw?

Factors are Glass Type (3 levels) and Temperature (3 levels).
Response is the Light output of an oscilloscope tube.
Hypotheses are:

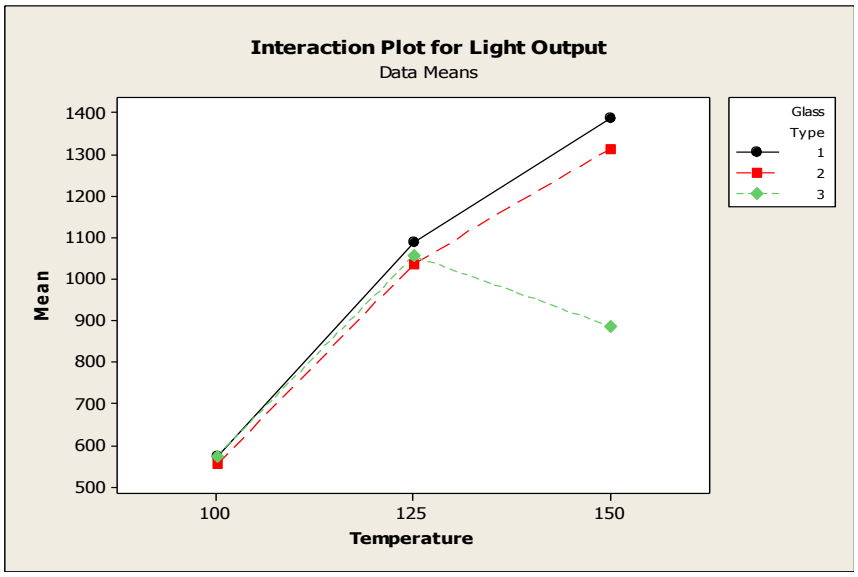
- For Glass Type (A): $H_o: \tau_1 = \tau_2 = \tau_3 = 0$, $H_1: at\ least\ one\ \neq 0$
- For Temperature (B): $H_o: \beta_1 = \beta_2 = \beta_3 = 0$, $H_1: at\ least\ one\ \neq 0$
- For Interaction (A*B): $H_o: (\tau\beta)_{ab} = 0$, $H_1: at\ least\ one\ \neq 0$

Confidence Level (α) = 0.05, and we will use the P-value to make conclusion depending on the rule of (If the P-value is Low the null must Go)

General Linear Model: Light Output versus Glass Type, Temperature

```
Factor       Type   Levels  Values
Glass Type   fixed       3  1, 2, 3
Temperature  fixed       3  100, 125, 150

Analysis of Variance for Light Output, using Adjusted SS for Tests

Source                  DF   Seq SS   Adj SS  Adj MS        F      P
Glass Type               2   150865   150865   75432   206.37  0.000
Temperature              2  1970335  1970335  985167  2695.26  0.000
Glass Type*Temperature   4   290552   290552   72638   198.73  0.000
Error                   18     6579     6579     366
Total                   26  2418330

S = 19.1185   R-Sq = 99.73%   R-Sq(adj) = 99.61%

Unusual Observations for Light Output

       Light
Obs   Output      Fit  SE Fit  Residual  St Resid
 13  1070.00  1035.00   11.04     35.00      2.24 R
 15  1000.00  1035.00   11.04    -35.00     -2.24 R

R denotes an observation with a large standardized residual.
```

Yes, there is a significant interactions effect. And both factors have affect the response.



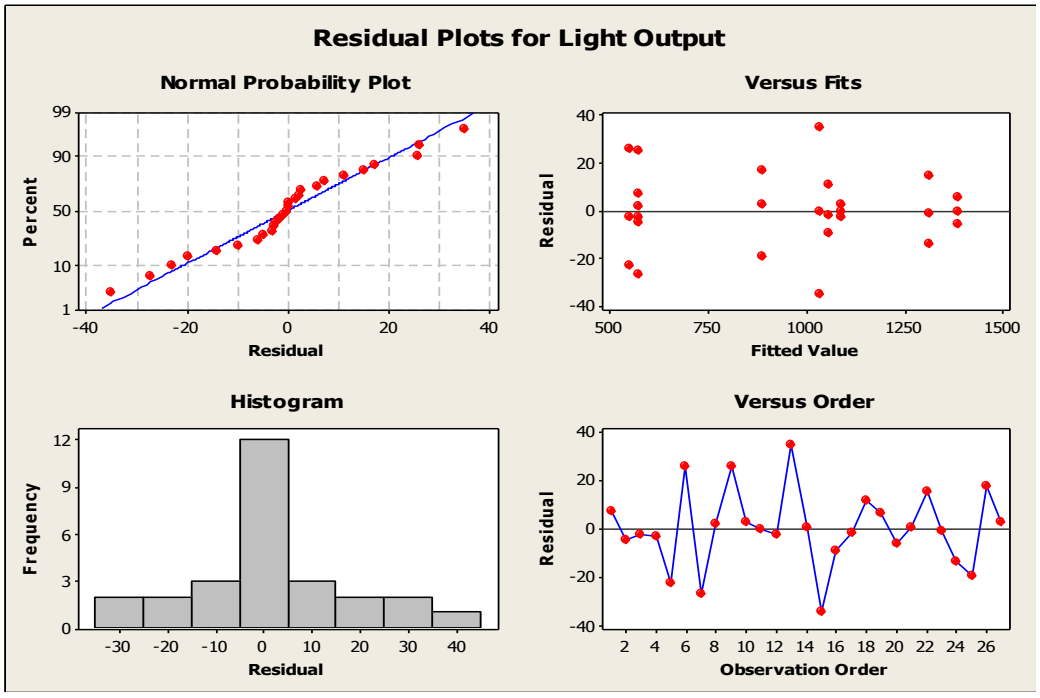
(b) Fit an appropriate model relating light output to glass type and temperature.

Term		Coef	SE Coef	T	P
Constant		940.185	3.679	255.53	0.000
Glass Type					
1		75.148	5.203	14.44	0.000
2		26.815	5.203	5.15	0.000
Temperature					
100		-373.852	5.203	-71.85	0.000
125		118.815	5.203	22.83	0.000
Glass Type*Temperature					
1	100	-68.815	7.359	-9.35	0.000
1	125	-46.815	7.359	-6.36	0.000
2	100	-40.148	7.359	-5.46	0.000
2	125	-50.815	7.359	-6.91	0.000

From Minitab output the appropriate model will be:

$$y = 940.185 + 75.148\,A_1 + 26.815A_2 - 373.852B_1 + 118.815B_2 - 68.815A_1B_1 - 46.815A_1B_2 - 40.148A_2B_1 - 50.815A_2B_2$$

(c) Analyze the residuals from this experiment. Comment on the adequacy of the models you have considered.



Using the 4 in 1 plot from Minitab to analyze the residuals and from the plots we can verify the assumptions (The residuals are normality distributed with mean of Zero and constant variances):

From the normality plot the residuals are normality distributed, the means around zero and from the versus fits plot the variances seems constant.