

## APENDICE C

### ANALISIS

| Response: ALTURA ESPUMA |             |       |         |          |          |
|-------------------------|-------------|-------|---------|----------|----------|
| Factor                  | Name        | Units | Type    | -1 Level | +1 Level |
| A                       | DEA         | %     | Numeric | 16.4645  | 23.5355  |
| B                       | MDEA        | %     | Numeric | 18.0806  | 26.9194  |
| C                       | EG          | %     | Numeric | 8.23223  | 11.7678  |
| D                       | TEMPERATURA | C     | Numeric | 41.3327  | 64.6673  |
| E                       | FLUJO       | SCFH  | Numeric | 22.9289  | 37.0711  |
| F                       | COMPOSICIÓN | %     | Numeric | 22.9289  | 37.0711  |

| Sequential Model Sum of Squares |                |    |             |         |          |
|---------------------------------|----------------|----|-------------|---------|----------|
| Source                          | Sum of Squares | DF | Mean Square | F Value | Prob > F |
| Mean                            | 29841.9        | 1  | 29841.9     |         |          |
| Linear                          | 223.357        | 6  | 37.2261     | 55.7655 | < 0.0001 |
| Quadratic                       | 15.9986        | 21 | 0.761836    | 1.20276 | 0.2835   |
| Cubic                           | 19.1745        | 26 | 0.737481    | 1.34368 | 0.2119   |
| Residual                        | 17.5632        | 32 | 0.54885     |         |          |
| Total                           | 30118          | 86 | 350.209     |         |          |

"Sequential Model Sum of Squares": Select the highest order polynomial where the additional terms are significant.

| Lack of Fit Tests |                |    |             |         |          |
|-------------------|----------------|----|-------------|---------|----------|
| Source            | Sum of Squares | DF | Mean Square | F Value | Prob > F |
| Linear            | 50.6363        | 70 | 0.723375    | 3.10018 | 0.0351   |
| Quadratic         | 34.6377        | 49 | 0.706892    | 3.02954 | 0.0392   |
| Cubic             | 15.4632        | 23 | 0.672313    | 2.88134 | 0.0514   |
| Pure Error        | 2.1            | 9  | 0.233333    |         |          |

"Lack of Fit Tests": Want the selected model to have insignificant lack-of-fit.

| Model Summary Statistics |          |           |                    |                     |         |
|--------------------------|----------|-----------|--------------------|---------------------|---------|
| Source                   | Root MSE | R-Squared | Adjusted R-Squared | Predicted R-Squared | PRESS   |
| Linear                   | 0.817036 | 0.808991  | 0.794484           | 0.771095            | 63.1991 |
| Quadratic                | 0.79587  | 0.866937  | 0.804994           | 0.678775            | 88.6879 |
| Cubic                    | 0.740844 | 0.936387  | 0.831027           | 0.437803            | 155.219 |

"Model Summary Statistics": Focus on the model minimizing the "PRESS", or equivalently maximizing the "PRED R-SQR".

**ANOVA**

| Response: ALTURA ESPUMA |             |       |         |          |          |
|-------------------------|-------------|-------|---------|----------|----------|
| Factor                  | Name        | Units | Type    | -1 Level | +1 Level |
| A                       | DEA         | %     | Numeric | 16.4645  | 23.5355  |
| B                       | MDEA        | %     | Numeric | 18.0806  | 26.9194  |
| C                       | EG          | %     | Numeric | 8.23223  | 11.7678  |
| D                       | EMPERATUR   | C     | Numeric | 41.3327  | 64.6673  |
| E                       | FLUJO       | SCFH  | Numeric | 22.9289  | 37.0711  |
| F                       | COMPOSICIÓN | %     | Numeric | 22.9289  | 37.0711  |

ANOVA for Response Surface Linear Model

| Source      | Sum of Squares | DF | Mean Square | F Value | Prob > F |
|-------------|----------------|----|-------------|---------|----------|
| Model       | 223.357        | 6  | 37.2261     | 55.7655 | < 0.0001 |
| Residual    | 52.7363        | 79 | 0.667548    |         |          |
| Lack of Fit | 50.6363        | 70 | 0.723375    | 3.10018 | 0.0351   |
| Pure Error  | 2.1            | 9  | 0.233333    |         |          |
| Cor Total   | 276.093        | 85 |             |         |          |

|          |          |
|----------|----------|
| Root MSE | 0.817036 |
| Dep Mean | 18.6279  |
| C.V.     | 4.38609  |
| PRESS    | 63.1991  |

|                |          |
|----------------|----------|
| R-Squared      | 0.808991 |
| Adj R-Squared  | 0.794484 |
| Pred R-Squared | 0.771095 |
| Adeq Precision | 30.5774  |
| Desire >       | 4        |

| Análisis de los factores que intervienen principalmente en la formación de espuma |                  |          |                  |                 |                    |          |
|---|------------------|----------|------------------|-----------------|--------------------|----------|
|   | Coefficient      |          | Standard         | t for H0        |                    |          |
| Factor  | Estimate         | DF       | Error            | Coeff=0         | Prob >  t          | VIF      |
| Intercept   | 18.6279          | 1        | 0.0881033        |                 |                    |          |
| A-DEA   | 0.172855         | 1        | 0.0913474        | 1.89229         | 0.0621             | 1        |
| <b>B-MDEA</b>   | <b>-0.699632</b> | <b>1</b> | <b>0.0913474</b> | <b>-7.65903</b> | <b>&lt; 0.0001</b> | <b>1</b> |
| <b>C-EG</b>   | <b>-0.824632</b> | <b>1</b> | <b>0.0913474</b> | <b>-9.02743</b> | <b>&lt; 0.0001</b> | <b>1</b> |
| D-TEMPERATURA   | -0.0478553       | 1        | 0.0913474        | -0.523883       | 0.6018             | 1        |
| E-FLUJO   | -0.0521447       | 1        | 0.0913474        | -0.570839       | 0.5697             | 1        |
| <b>F-COMPOSICIÓN</b>  | <b>1.25999</b>   | <b>1</b> | <b>0.0913474</b> | <b>13.7934</b>  | <b>&lt; 0.0001</b> | <b>1</b> |

Final Equation in Terms of Coded Factors:

$$\begin{aligned}
 \text{ALTURA ESP} = & 18.6279 \\
 & 0.172855 * A \\
 & -0.699632 * B \\
 & -0.824632 * C \\
 & -0.0478553 * D \\
 & -0.0521447 * E \\
 & 1.25999 * F
 \end{aligned}$$

Final Equation in Terms of Actual Factors:

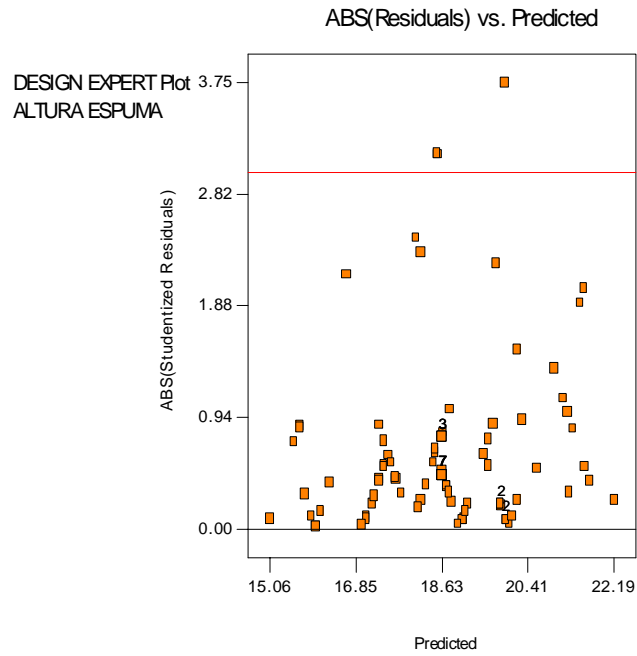
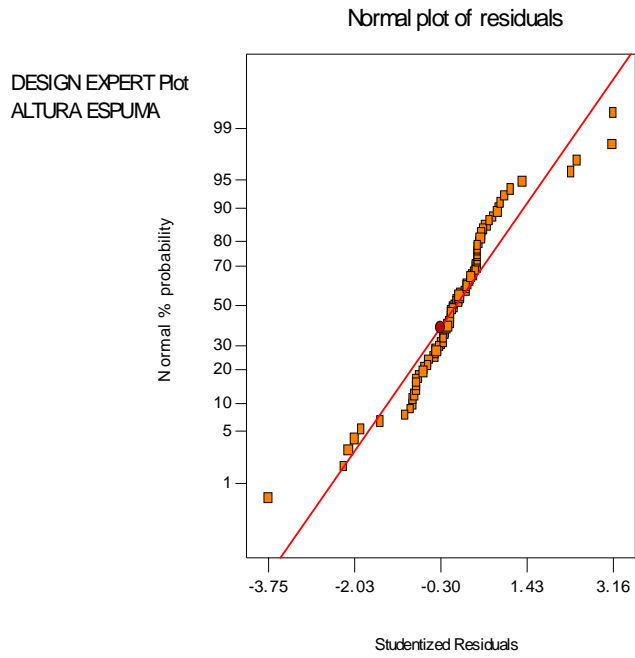
$$\begin{aligned} \text{ALTURA} = & \\ & 20.97 \\ & 0.0489 * \text{DEA} \\ & -0.1583 * \text{MDEA} \\ & -0.4665 * \text{EG} \\ & -0.0041 * \text{TEMPERATURA} \\ & -0.0074 * \text{FLUJO} \\ & 0.1782 * \text{COMPOSICIÓN} \end{aligned}$$

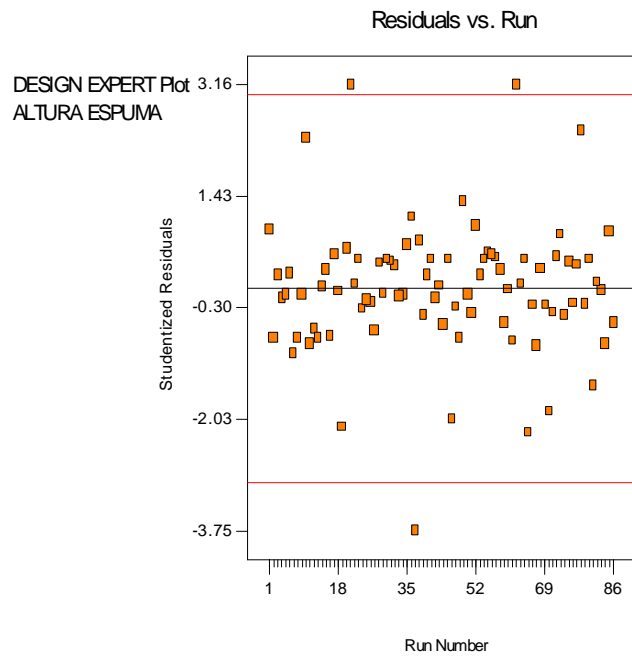
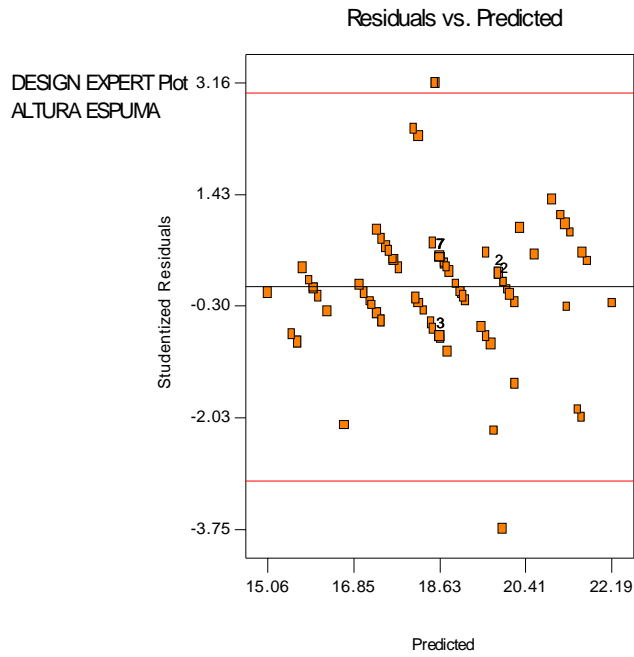
| Diagnostics Case Statistics |              |                 |            |           |                  |                 |            |           |
|-----------------------------|--------------|-----------------|------------|-----------|------------------|-----------------|------------|-----------|
| Standard Order              | Actual Value | Predicted Value | Residual   | Leverage  | Student Residual | Cook's Distance | Outlier t  | Run Order |
| 1                           | 19           | 18.8193         | 0.180672   | 0.0866279 | 0.23138          | 0.000725        | 0.229988   | 6         |
| 2                           | 19           | 19.165          | -0.165039  | 0.0866279 | -0.211359        | 0.000605        | -0.210077  | 26        |
| 3                           | 17           | 17.4201         | -0.420064  | 0.0866279 | -0.537961        | 0.003921        | -0.535527  | 86        |
| 4                           | 18           | 17.7658         | 0.234225   | 0.0866279 | 0.299963         | 0.001219        | 0.298229   | 15        |
| 5                           | 17           | 17.1701         | -0.170064  | 0.0866279 | -0.217795        | 0.000643        | -0.216477  | 76        |
| 6                           | 18           | 17.5158         | 0.484225   | 0.0866279 | 0.620129         | 0.00521         | 0.617697   | 20        |
| 7                           | 16           | 15.7708         | 0.2292     | 0.0866279 | 0.293528         | 0.001167        | 0.291823   | 58        |
| 8                           | 16           | 16.1165         | -0.116511  | 0.0866279 | -0.149211        | 0.000302        | -0.148285  | 4         |
| 9                           | 19           | 18.7236         | 0.276382   | 0.0866279 | 0.353953         | 0.001697        | 0.351985   | 32        |
| 10                          | 19           | 19.0693         | -0.0693283 | 0.0866279 | -0.0887862       | 0.000107        | -0.0882269 | 9         |
| 11                          | 17           | 17.3244         | -0.324354  | 0.0866279 | -0.415388        | 0.002338        | -0.413202  | 39        |
| 12                          | 18           | 17.6701         | 0.329936   | 0.0866279 | 0.422537         | 0.002419        | 0.420329   | 75        |
| 13                          | 17           | 17.0744         | -0.0743536 | 0.0866279 | -0.0952219       | 0.000123        | -0.0946227 | 5         |
| 14                          | 18           | 17.4201         | 0.579936   | 0.0866279 | 0.742702         | 0.007474        | 0.740577   | 38        |
| 15                          | 15           | 15.6751         | -0.67509   | 0.0866279 | -0.864562        | 0.010128        | -0.863166  | 84        |
| 16                          | 16           | 16.0208         | -0.0208002 | 0.0866279 | -0.026638        | 9.61E-06        | -0.026469  | 83        |
| 17                          | 19           | 18.715          | 0.284961   | 0.0866279 | 0.364939         | 0.001804        | 0.362928   | 77        |
| 18                          | 19           | 19.0607         | -0.0607497 | 0.0866279 | -0.0777999       | 8.2E-05         | -0.0773089 | 29        |
| 19                          | 17           | 17.3158         | -0.315775  | 0.0866279 | -0.404401        | 0.002216        | -0.40225   | 74        |
| 20                          | 18           | 17.6615         | 0.338514   | 0.0866279 | 0.433523         | 0.002546        | 0.431284   | 31        |
| 21                          | 17           | 17.0658         | -0.0657749 | 0.0866279 | -0.0842356       | 9.61E-05        | -0.0837045 | 34        |
| 22                          | 17           | 17.4115         | -0.411486  | 0.0866279 | -0.526975        | 0.003763        | -0.524551  | 59        |
| 23                          | 15           | 15.6665         | -0.666511  | 0.0866279 | -0.853576        | 0.009872        | -0.852095  | 11        |
| 24                          | 16           | 16.0122         | -0.0122216 | 0.0866279 | -0.0156517       | 3.32E-06        | -0.0155523 | 60        |
| 25                          | 19           | 18.6193         | 0.380672   | 0.0866279 | 0.487512         | 0.00322         | 0.485147   | 57        |
| 26                          | 19           | 18.965          | 0.034961   | 0.0866279 | 0.0447733        | 2.72E-05        | 0.0444895  | 43        |
| 27                          | 17           | 17.2201         | -0.220064  | 0.0866279 | -0.281828        | 0.001076        | -0.28018   | 47        |
| 28                          | 18           | 17.5658         | 0.434225   | 0.0866279 | 0.556096         | 0.00419         | 0.55365    | 55        |
| 29                          | 17           | 16.9701         | 0.0299357  | 0.0866279 | 0.0383376        | 1.99E-05        | 0.0380945  | 14        |
| 30                          | 18           | 17.3158         | 0.684225   | 0.0866279 | 0.876262         | 0.010404        | 0.874961   | 85        |
| 31                          | 15           | 15.5708         | -0.5708    | 0.0866279 | -0.731003        | 0.00724         | -0.728831  | 16        |
| 32                          | 16           | 15.9165         | 0.0834891  | 0.0866279 | 0.106921         | 0.000155        | 0.10625    | 82        |
| 33                          | 22           | 21.3393         | 0.660697   | 0.0866279 | 0.84613          | 0.0097          | 0.844594   | 73        |
| 34                          | 22           | 21.685          | 0.314986   | 0.0866279 | 0.403391         | 0.002205        | 0.401244   | 28        |
| 35                          | 20           | 19.94           | 0.059961   | 0.0866279 | 0.0767898        | 7.99E-05        | 0.0763051  | 22        |
| 36                          | 21           | 20.2857         | 0.71425    | 0.0866279 | 0.914714         | 0.011337        | 0.913758   | 1         |

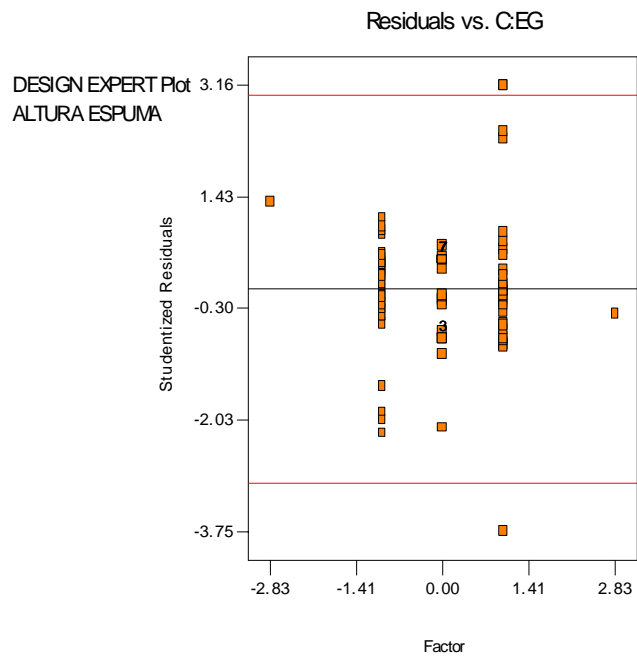
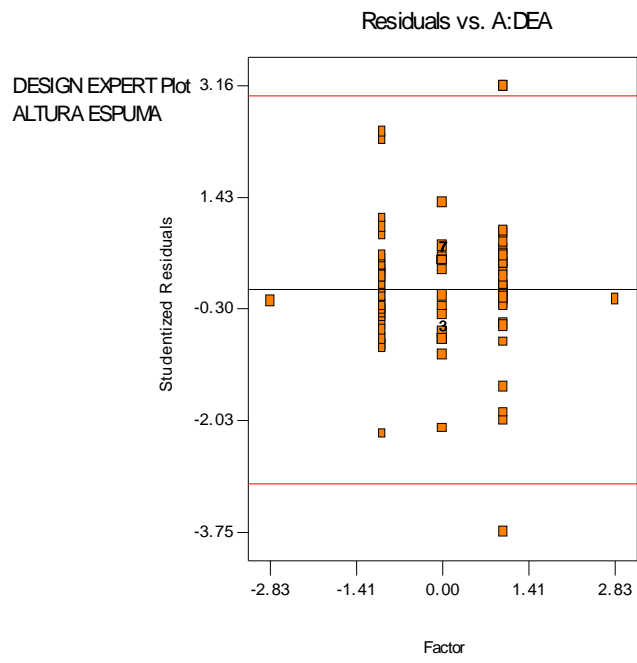
|    |    |         |            |           |            |          |            |    |
|----|----|---------|------------|-----------|------------|----------|------------|----|
| 37 | 19 | 19.69   | -0.690039  | 0.0866279 | -0.883708  | 0.010581 | -0.882469  | 67 |
| 38 | 20 | 20.0357 | -0.0357497 | 0.0866279 | -0.0457833 | 2.84E-05 | -0.0454932 | 18 |
| 39 | 18 | 18.2908 | -0.290775  | 0.0866279 | -0.372385  | 0.001879 | -0.370346  | 71 |
| 40 | 18 | 18.6365 | -0.636486  | 0.0866279 | -0.815124  | 0.009002 | -0.813376  | 61 |
| 41 | 21 | 21.2436 | -0.243592  | 0.0866279 | -0.31196   | 0.001319 | -0.31017   | 24 |
| 42 | 22 | 21.5893 | 0.410697   | 0.0866279 | 0.525964   | 0.003748 | 0.523542   | 56 |
| 43 | 20 | 19.8443 | 0.155672   | 0.0866279 | 0.199363   | 0.000539 | 0.198147   | 53 |
| 44 | 20 | 20.19   | -0.190039  | 0.0866279 | -0.243376  | 0.000803 | -0.241921  | 79 |
| 45 | 19 | 19.5943 | -0.594328  | 0.0866279 | -0.761134  | 0.007849 | -0.75909   | 48 |
| 46 | 20 | 19.94   | 0.059961   | 0.0866279 | 0.0767898  | 7.99E-05 | 0.0763051  | 63 |
| 47 | 18 | 18.1951 | -0.195064  | 0.0866279 | -0.249812  | 0.000846 | -0.248324  | 66 |
| 48 | 21 | 18.5408 | 2.45923    | 0.0866279 | 3.14944    | 0.134394 | 3.34658    | 21 |
| 49 | 22 | 21.235  | 0.764986   | 0.0866279 | 0.97969    | 0.013004 | 0.979437   | 52 |
| 50 | 20 | 21.5807 | -1.58072   | 0.0866279 | -2.02438   | 0.055526 | -2.06582   | 46 |
| 51 | 20 | 19.8357 | 0.16425    | 0.0866279 | 0.210349   | 0.0006   | 0.209072   | 3  |
| 52 | 19 | 20.1815 | -1.18146   | 0.0866279 | -1.51305   | 0.031019 | -1.52572   | 81 |
| 53 | 20 | 19.5857 | 0.41425    | 0.0866279 | 0.530515   | 0.003813 | 0.528088   | 17 |
| 54 | 17 | 19.9315 | -2.93146   | 0.0866279 | -3.75421   | 0.190963 | -4.116 *   | 37 |
| 55 | 20 | 18.1865 | 1.81351    | 0.0866279 | 2.3225     | 0.073084 | 2.39082    | 10 |
| 56 | 21 | 18.5322 | 2.4678     | 0.0866279 | 3.16043    | 0.135333 | 3.35994    | 62 |
| 57 | 22 | 21.1393 | 0.860697   | 0.0866279 | 1.10226    | 0.016462 | 1.10379    | 36 |
| 58 | 20 | 21.485  | -1.48501   | 0.0866279 | -1.9018    | 0.049005 | -1.93453   | 70 |
| 59 | 18 | 19.74   | -1.74004   | 0.0866279 | -2.2284    | 0.067282 | -2.28731   | 65 |
| 60 | 20 | 20.0857 | -0.0857497 | 0.0866279 | -0.109816  | 0.000163 | -0.109128  | 33 |
| 61 | 19 | 19.49   | -0.490039  | 0.0866279 | -0.627575  | 0.005336 | -0.625151  | 12 |
| 62 | 20 | 19.8357 | 0.16425    | 0.0866279 | 0.210349   | 0.0006   | 0.209072   | 40 |
| 63 | 20 | 18.0908 | 1.90923    | 0.0866279 | 2.44507    | 0.081002 | 2.52705    | 78 |
| 64 | 18 | 18.4365 | -0.436486  | 0.0866279 | -0.558991  | 0.004234 | -0.556544  | 44 |
| 65 | 18 | 18.139  | -0.138998  | 0.111628  | -0.180497  | 0.000585 | -0.179388  | 25 |
| 66 | 19 | 19.1168 | -0.116816  | 0.111628  | -0.151692  | 0.000413 | -0.150751  | 42 |
| 67 | 21 | 20.6068 | 0.393235   | 0.111628  | 0.510638   | 0.004681 | 0.508235   | 72 |
| 68 | 15 | 16.649  | -1.64905   | 0.111628  | -2.14139   | 0.082313 | -2.19237   | 19 |
| 69 | 22 | 20.9603 | 1.03968    | 0.111628  | 1.35009    | 0.032719 | 1.35726    | 49 |
| 70 | 16 | 16.2955 | -0.295495  | 0.111628  | -0.383718  | 0.002643 | -0.381637  | 51 |
| 71 | 19 | 18.7633 | 0.236738   | 0.111628  | 0.307418   | 0.001696 | 0.305649   | 68 |
| 72 | 18 | 18.4926 | -0.492552  | 0.111628  | -0.639607  | 0.007344 | -0.637198  | 27 |
| 73 | 18 | 18.7754 | -0.775394  | 0.111628  | -1.00689   | 0.018199 | -1.00698   | 7  |
| 74 | 19 | 18.4804 | 0.51958    | 0.111628  | 0.674705   | 0.008172 | 0.672361   | 35 |
| 75 | 15 | 15.0641 | -0.0641245 | 0.111628  | -0.0832694 | 0.000124 | -0.0827443 | 50 |
| 76 | 22 | 22.1917 | -0.191689  | 0.111628  | -0.24892   | 0.001112 | -0.247436  | 69 |
| 77 | 19 | 18.6279 | 0.372093   | 0.0116279 | 0.458089   | 0.000353 | 0.455786   | 41 |
| 78 | 19 | 18.6279 | 0.372093   | 0.0116279 | 0.458089   | 0.000353 | 0.455786   | 23 |
| 79 | 19 | 18.6279 | 0.372093   | 0.0116279 | 0.458089   | 0.000353 | 0.455786   | 80 |
| 80 | 18 | 18.6279 | -0.627907  | 0.0116279 | -0.773026  | 0.001004 | -0.771039  | 2  |
| 81 | 19 | 18.6279 | 0.372093   | 0.0116279 | 0.458089   | 0.000353 | 0.455786   | 45 |
| 82 | 19 | 18.6279 | 0.372093   | 0.0116279 | 0.458089   | 0.000353 | 0.455786   | 54 |
| 83 | 19 | 18.6279 | 0.372093   | 0.0116279 | 0.458089   | 0.000353 | 0.455786   | 64 |
| 84 | 19 | 18.6279 | 0.372093   | 0.0116279 | 0.458089   | 0.000353 | 0.455786   | 30 |
| 85 | 18 | 18.6279 | -0.627907  | 0.0116279 | -0.773026  | 0.001004 | -0.771039  | 13 |
| 86 | 18 | 18.6279 | -0.627907  | 0.0116279 | -0.773026  | 0.001004 | -0.771039  | 8  |

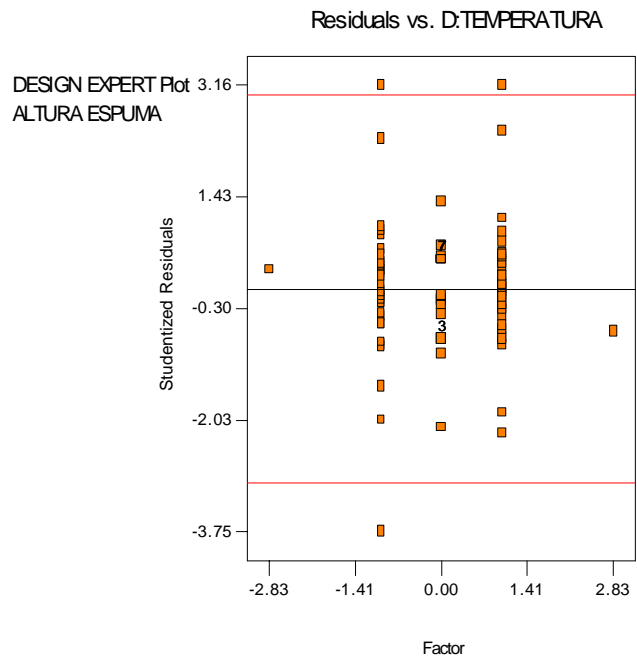
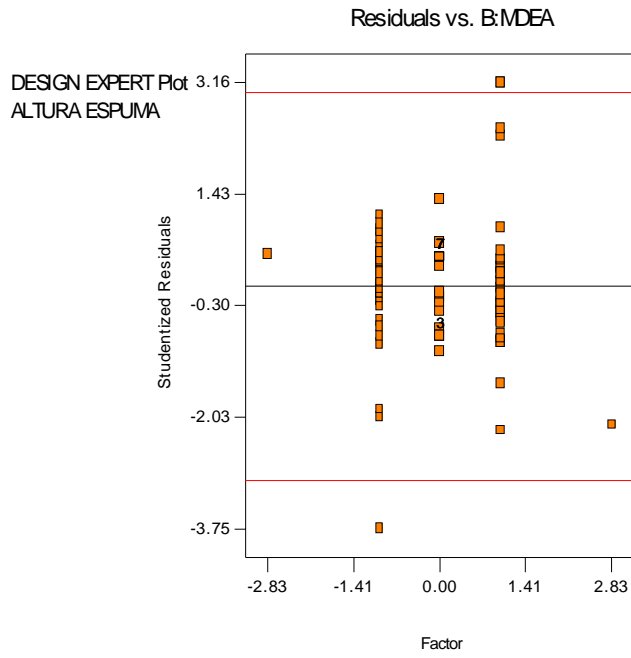
with |Outlier T| > 3.50

DIAGNÓSTICO ESTADÍSTICO (ALTURA DE ESPUMA)

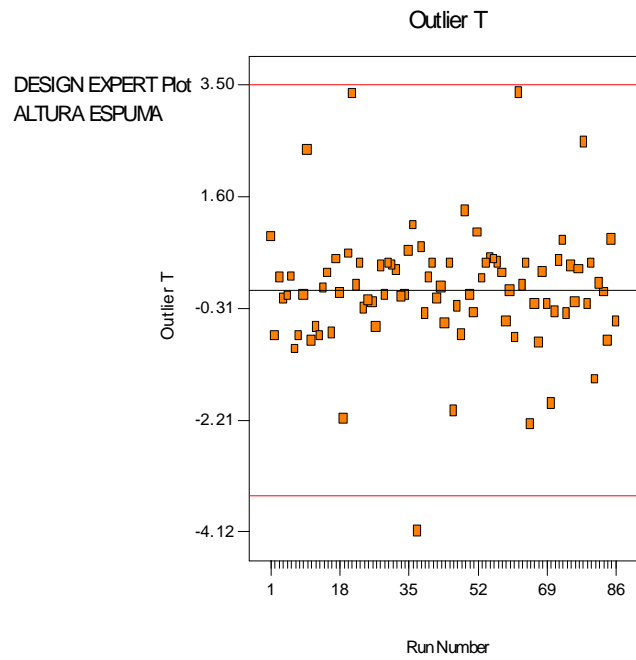
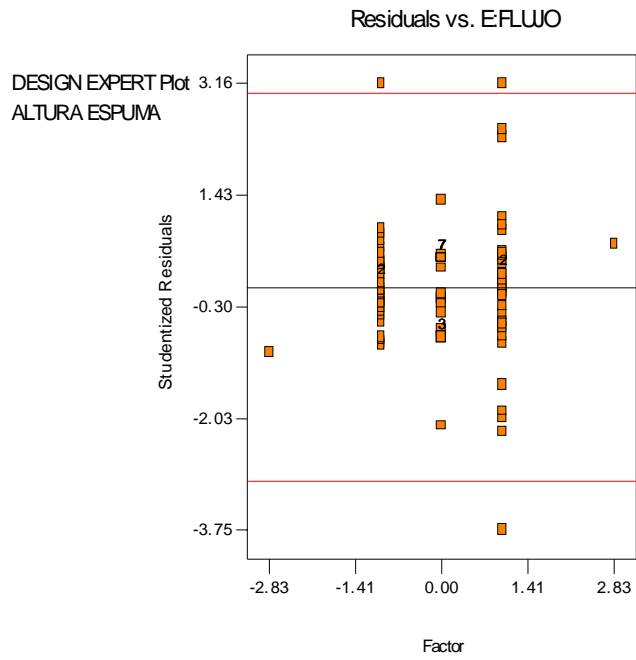




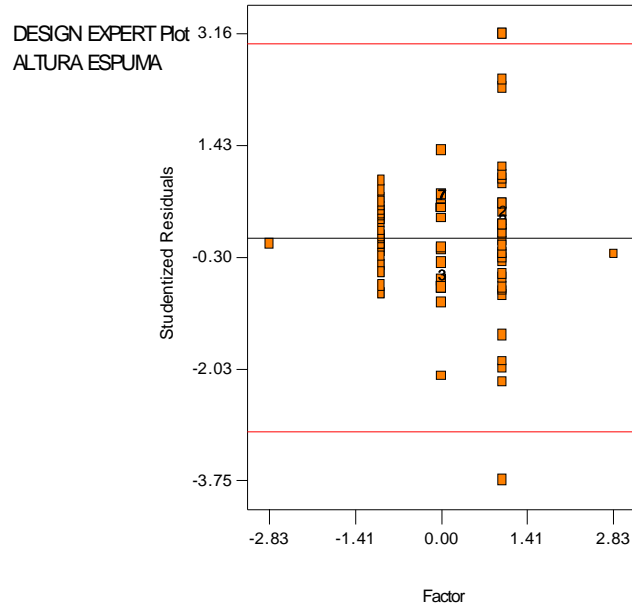








Residuals vs. F:COMPOSICIÓN



Cook's Distance

