```
(ch6-3-VacTubes_HO1.out)
 DATA tubes;
   INFILE file1  FIRSTOBS=2 EXPANDTABS;
   INPUT exhaust voltage treat_comb pressure;

*Create an interaction plot;
 PROC SORT DATA=tubes;
   BY exhaust voltage;
 PROC MEANS DATA=tubes NOPRINT;
   VAR pressure;
   BY exhaust voltage;
   OUTPUT OUT=tubes2 MEAN=cellmean;
 PROC GPLOT DATA=tubes2;
   SYMBOL1 INTERPOL=SPLINE COLOR=GREEN VALUE=CIRCLE;
   SYMBOL2 INTERPOL=SPLINE COLOR=BLUE  VALUE=SQUARE;
   SYMBOL3 INTERPOL=SPLINE COLOR=RED   VALUE=TRIANGLE;
   PLOT cellmean*exhaust=voltage;

 PROC GLM DATA=tubes;
   CLASS  voltage exhaust;
   MODEL  pressure = voltage exhaust voltage*exhaust;                          *(a);

   MEANS   exhaust;                                                            *(b);
   LSMEANS exhaust         / STDERR CL; *CL asks for Confidence Limits;        *(c);
   LSMEANS voltage*exhaust / STDERR CL;

  *Orthogonal poly contrasts for Main Effects;                                 *(d-1);
   CONTRAST 'exhaust_lin '  exhaust -1  0  1;
   CONTRAST 'exhaust_quad'  exhaust  1 -2  1;

  *Orthogonal poly contrasts for Interaction Effects;
  *NB: the order in the CLASS statement sets the parameterization of the design matrix;
                               *           V1         V2         V3      ;
                               *           E1 E2 E3   E1 E2 E3   E1 E2 E3;
                               * V1-vs-V3: -1 -1 -1    0  0  0    1  1  1;
                               * V2-vs-V3:  0  0  0   -1 -1 -1    1  1  1;
                               *                                        ;
                               * E_linear: -1  0  1   -1  0  1   -1  0  1;
                               * E_quadra:  1 -2  1    1 -2  1    1 -2  1;

   CONTRAST 'E_lin  * V  ' voltage*exhaust  1  0 -1    0  0  0   -1  0  1,
                           voltage*exhaust  0  0  0    1  0 -1   -1  0  1 ;    *(d-2);
   CONTRAST 'E_quad * V  ' voltage*exhaust -1  2 -1    0  0  0    1 -2  1,
                           voltage*exhaust  0  0  0   -1  2 -1    1 -2  1 ;

   CONTRAST 'E_lin in V1'
          exhaust  1  0 -1 voltage*exhaust  1  0 -1    0  0  0    0  0  0;    *(d-3);
   CONTRAST 'E_lin in V2'
          exhaust  1  0 -1 voltage*exhaust  0  0  0    1  0 -1    0  0  0;
   CONTRAST 'E_lin in V3'
          exhaust  1  0 -1 voltage*exhaust  0  0  0    0  0  0    1  0 -1;

   CONTRAST 'E_quad in V1'
          exhaust  1 -2  1 voltage*exhaust  1 -2  1    0  0  0    0  0  0;    *(d-4);
   CONTRAST 'E_quad in V2'
          exhaust  1 -2  1 voltage*exhaust  0  0  0    1 -2  1    0  0  0;
   CONTRAST 'E_quad in V3'
          exhaust  1 -2  1 voltage*exhaust  0  0  0    0  0  0    1 -2  1;

   CONTRAST 'exhaust in V1'
          exhaust -1  0  1 voltage*exhaust -1  0  1    0  0  0    0  0  0,
          exhaust  0 -1  1 voltage*exhaust  0 -1  1    0  0  0    0  0  0 ;    *(d-5);
   CONTRAST 'exhaust in V2'
          exhaust -1  0  1 voltage*exhaust  0  0  0   -1  0  1    0  0  0,
          exhaust  0 -1  1 voltage*exhaust  0  0  0    0 -1  1    0  0  0 ;
   CONTRAST 'exhaust in V3'
          exhaust -1  0  1 voltage*exhaust  0  0  0    0  0  0   -1  0  1,
          exhaust  0 -1  1 voltage*exhaust  0  0  0    0  0  0    0 -1  1 ;

  *Slicing interactions;                                                       *(e);

   LSMEANS voltage*exhaust / SLICE=voltage;    RUN;
```

```
   Class         Levels    Values
   voltage            3    120 170 220
   exhaust            3    60  90  120
a)
   Source                     DF   SumOfSquares    Mean Square   F Value   Pr > F
   Model                       8    6532.444444     816.555556     50.34   <.0001
   Error                       9     146.000000      16.222222
   Corrected Total            17    6678.444444

   Source                     DF    Type III SS    Mean Square   F Value   Pr > F
   voltage                     2     140.777778      70.388889      4.34   0.0479
   exhaust                     2    6044.111111    3022.055556    186.29   <.0001
   voltage*exhaust             4     347.555556      86.888889      5.36   0.0174

b)
   Level of        ----------pressure----------
   exhaust     N           Mean          Std Dev
   60          6     52.5000000       6.62570751
   90          6     21.1666667       8.54205284
   120         6      9.0000000       3.16227766

                     pressure        Standard
   exhaust            LSMEAN           Error    Pr > |t|    95% Confidence Limits
   60             52.5000000       1.6442943      <.0001    48.780348   56.219652
   90             21.1666667       1.6442943      <.0001    17.447015   24.886319
   120             9.0000000       1.6442943      0.0004     5.280348   12.719652

 c)
   Least Squares Means (voltage*exhaust)
                                 pressure        Standard
    voltage    exhaust            LSMEAN           Error    Pr > |t|    95% Conf Limits
    120        60             53.0000000       2.8480012      <.0001     46.557  59.442
    120        90             30.5000000       2.8480012      <.0001     24.057  36.942
    120        120            11.0000000       2.8480012      0.0038      4.557  17.442
    170        60             46.5000000       2.8480012      <.0001     40.057  52.942
    170        90             21.0000000       2.8480012      <.0001     14.557  27.442
    170        120             8.5000000       2.8480012      0.0153      2.057  14.942
    220        60             58.0000000       2.8480012      <.0001     51.557  64.442
    220        90             12.0000000       2.8480012      0.0023      5.557  18.442
    220        120             7.5000000       2.8480012      0.0272      1.057  13.942

 d)
      Contrast                   DF    Contrast SS    Mean Square   F Value   Pr > F

    1) exhaust_lin                1    5676.750000    5676.750000    349.94   <.0001
       exhaust_quad               1     367.361111     367.361111     22.65   0.0010

    2) E_lin  * V                 2      81.500000      40.750000      2.51   0.1359
       E_quad * V                 2     266.055556     133.027778      8.20   0.0094

    3) E_lin in V1                1    1764.000000    1764.000000    108.74   <.0001
       E_lin in V2                1    1444.000000    1444.000000     89.01   <.0001
       E_lin in V3                1    2550.250000    2550.250000    157.21   <.0001

    4) E_quad in V1               1       3.000000       3.000000      0.18   0.6773
       E_quad in V2               1      56.333333      56.333333      3.47   0.0953
       E_quad in V3               1     574.083333     574.083333     35.39   0.0002

    5) exhaust in V1              2    1767.000000     883.500000     54.46   <.0001
       exhaust in V2              2    1500.333333     750.166667     46.24   <.0001
       exhaust in V3              2    3124.333333    1562.166667     96.30   <.0001

 e)
   voltage*exhaust Effect Sliced by voltage for pressure

   voltage        DF    SumOfSquares     Mean Square    F Value    Pr > F
   120             2    1767.000000      883.500000      54.46    <.0001
   170             2    1500.333333      750.166667      46.24    <.0001
   220             2    3124.333333     1562.166667      96.30    <.0001
```