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A Comparison of Commercial Design of Experiment Software Programs for the Analysis of Durability Data

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CONTENTS

A Comparison of Commercial Design of Experiment Software Programs for the Analysis of Durability Data

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ABSTRACT

Following the success of the design of experiments technique, DOE, in providing optimal solutions for manufacturing case studies carried out in a previous research project, MTS Adhesive Project 5: Measurements for Optimising Adhesives Processing[1], the DOE techniques were felt to provide a basis for the determination of the critical environmental factors and the relationship between these factors for durability tests on adhesive joints. A large number of commercial DOE software programs are available. In this report a number of these programs are compared to a proprietary program XYRATEX-AGSS. The results indicate that comparing DOE programs is not straightforward. The program specific organisation of the factors within the arrays in these software programs requires that the user must be aware of the representation of the 'standard' arrays within their chosen software package especially when cross referencing data with other workers using a different utility.

The second part of this report uses DOE techniques to analyse a durability study of AV119 single part epoxy adhesive using single perforated lap joints tests and a full factorial analysis

This result of this study indicates;

i) the number of holes introduced after the initial perforation does not have a major effect on the failure load; i.e. there is no accelerated degradation due to the penetration of moisture into the adhesive due to the perforations

ii) there is no reduction of the structural integrity with the introduction of more than one perforation into the lap joint

iii) temperature and time factors seem to have the greatest influence on the adhesive joint durability.

1. INTRODUCTION

The previous research project; MTS Adhesives project 5: Measurements for Optimising Adhesives Processing introduced the use of design of experiment techniques, DOE, for the optimisation of a number of manufacturing processes[1] which included an adhesive bonding stage.

The DOE techniques employed were felt to provide the basis for the development of a framework in determining the critical factors and the relationship between these factors for environmental durability testing on adhesive joints. This framework would be used to establish procedures for accelerated test regimes. The software that was used in providing the solution to the experimental design was a proprietary package developed by IBM called AGSS, Advanced Graphical Statistical System. Due to the familiarity with the AGSS system and the rigorous on-site validated testing available, AGSS was used as the reference against which commercial DOE programs were evaluated. A group of reference data sets[2] were derived based on a previous case study[3].

This report, DTI MTS Adhesives Programme 1996-1999: Performance of Adhesive Joints. Project 3: Combined Cyclic Loading and Hostile Environments, Development of Data Sets for the Evaluation of Design of Experiments Software Packages by M Hall & T Twine[2], is included as an addendum to this report.

The commercial software packages investigated are detailed in Table 1.

Package	Supplier	Operating system
DOE Wisdom	Launsby Consulting USA	Windows 3.1 and Windows 95
Q-EDGE	Air Academy Associates USA	Windows 3.1
DOE KISS for Excel	Air Academy Associates USA	Windows 3.1 and Microsoft Excel
DOE-PC IV	Quality America Inc. USA	Windows 3.1
Qualitek-4	Nutek Inc. USA	Windows 3.1

Table 1 - Commercial DOE software packages investigated

2 EXPERIMENTAL

The matrix selected for the experimental analysis was a Taguchi L_{16} - with fifteen factors sixteen experimental runs. For the application studied, steel plate bonding, only ten fa were assessed and thus only ten of the fifteen columns were populated (Table 2).

Run	Factor														
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2
3	1	1	1	2	2	2	2	1	1	1	1	2	2	2	2
4	1	1	1	2	2	2	2	2	2	2	2	1	1	1	1
5	1	2	2	1	1	2	2	1	1	2	2	1	1	2	2
6	1	2	2	1	1	2	2	2	2	1	1	2	2	1	1
7	1	2	2	2	2	1	1	1	1	2	2	2	2	1	1
8	1	2	2	2	2	1	1	2	2	1	1	1	1	2	2
9	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
10	2	1	2	1	2	1	2	2	1	2	1	2	1	2	1
11	2	1	2	2	1	2	1	1	2	1	2	2	1	2	1
12	2	1	2	2	1	2	1	2	1	2	1	1	2	1	2
13	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1
14	2	2	1	1	2	2	1	2	1	1	2	2	1	1	2
15	2	2	1	2	1	1	2	1	2	2	1	2	1	1	2
16	2	2	1	2	1	1	2	2	1	1	2	1	2	2	1

Table 2 - Representation of a Taguchi L_{16} array

The commercial packages assign an experiment array on the basis of the number of factors selected by the user. Therefore, in the programs where a choice was possible, a Taguchi L_{16} array was manually selected and edited to correspond to the AGSS array. Where this was not possible, the defining equations for the respective model as developed by Hall and Twine[2] were used to calculate the results for the experimental runs to correspond to the AGSS array.

3 RESULTS

The analysis output from each of the programs is shown for each program for models 1-4 in the Appendix.

As the software is not at hand for the reader of this report, it is difficult to fully demonstrate the complexities of the results presented. Table 3 summarises the basic results. The full analysis output of each of the DOE programs is given in the Appendix.

DOE Package	Matrix Used	Results of Statistical Analysis
Qualitek-4	Model 1-4 Matrix*	Similar to AGSS
DOE Wisdom	Taguchi L_{16}	Dissimilar to AGSS
DOE PC-IV	Model 1-4 Matrix*	Similar to AGSS
DOE KISS	Taguchi L_{16}	Dissimilar to AGSS
Quality EDGE	Taguchi L_{16}	Dissimilar to AGSS

* Model 1-4 Matrix = AGSS matrices[2]

Table 3 - Comparison of results on DOE analysis on case study of steel plate bonding[3]

4 COMPARISON OF DOE PROGRAMS - DISCUSSION

As the array of choice is the well-defined Taguchi L_{16} orthogonal array, the variation in the analysis output is somewhat confusing. One of the factors investigated to resolve these variations in the analysis were the arrays generated by the software packages. The result of this analysis is shown in Table 4A.

	Factors														
Columns	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Taguchi 16	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
AGSS	A	B	H	C	J	-	F	D	-	-	G	-	I	-	E
Qualitek	A	B	H	C	J	-	F	D	-	-	G	-	I	-	E
PC-IV	A	B	H	C	J	-	F	D	-	-	G	-	I	-	E
DOE Wisdom	A	B	-	C	-	-	F	D	-	-	G	J	H	E	I
DOE Kiss	A	B	E	C	F	H	-	D	G	I	-	J	-	-	-
Quality Edge	A	B	H	C	J	E	D	I	G	-	-	-	-	-	-

Taguchi L_{16} matrix = fifteen factors, sixteen experimental runs.

Table 4A - Placement of factors in columns for the steel plate bonding analysis array

The design of experiment array used in the case study of steel plate bonding had factors which correspond to the Taguchi L_{16} factors shown in Table 4B:

	Factors														
Columns	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Taguchi L_{16}	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Qualitek L_{16}	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
PC-IV L_{16}	A	B	E	C	F	G	K	D	H	I	L	J	M	N	O
DOE Wisdom L_{16}	**Not Available**														
DOE Kiss L_{16}	A	B	E	C	F	H	K	D	G	I	L	J	M	N	O
Quality Edge L_{16}	A	B	E	C	F	G	H	D	I	J	K	L	M	N	O

Table 4B - Comparison of commercial depiction of the fifteen factor L_{16} Taguchi array

Table 4B shows that the strict definition of a Taguchi array[4] is only followed in the Qualitek and PC IV packages. In addition the programming of these two software systems allows the editing of the base array to correspond with the defined AGSS array.

DOE KISS and the Quality Edge software packages either do not allow editing of the experiment arrays or return an error when analysis of the customised array is initiated. This error is associated with a perceived confounding* error in the modified array. The DOE Wisdom Package returns a 20 run Central Composite Design when using a fifteen factor input.

5 CONCLUSIONS

Clearly comparing DOE programs is not straightforward. The software programs produce arrays that deviate considerably from the original array. Whilst experimental runs can be performed in any order, randomisation is an essential feature of the DOE process, the program specific organisation of the factors within the arrays in these software programs must be taken into account. This is extremely important when comparisons are made with results obtained from another package. The experimental runs selected must be the same and placement of the factors must be in the same order. Where editing of the array is allowed, this procedure is relatively straightforward, for example, Qualitek 4 and PC IV, where the results from this program confirm the results of the AGSS analysis.

The user must be aware of the representation of the 'standard' arrays within their selected programme especially when cross referencing data with data from another DOE software program.

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* **Confounding:** Partial aliasing* of factors and interaction with each other.
* **Aliasing:** In a design matrix columns which are identical are said to be aliased
Aliasing prevents individual assessment of the factors

6 ANALYSIS OF AN ADHESIVE LAP JOINT DURABILITY STUDY

This section of this report discusses the use of DOE techniques to assess analytically a durability study of AV119 single part epoxy adhesive using simple lap joints tests. A full factorial approach was used to establish the relationship between the main factors and their interactions over a time period which would be representative for the development of an accelerated ageing test programme. This approach was used to aid in the evaluation of:

i) the potential of using a partial factorial system if a mathematical relationship could be established between the factors

ii) short term data from a durability study capable of describing long term effects

The full factorial matrix was analysed using Microsoft Excel Version 7 spreadsheet software

7 EXPERIMENTAL

Single lap joints were made from mild rolled CR1 steel adherend, supplied by British Steel Plc and with AV119 single part epoxy adhesive cured at 140°C for 75 minutes. The adhesive was supplied by Ciba Specialty Chemicals. The test consisted of tensile loading a single lap joint under ambient condition (23°C, 50% RH) at 1mm/min using an Instron 1196 test machine. The single lap joint consisted of two rectangular sections, 25 mm wide, 100mm long and 1.6mm thick, bonded together, with an overlap length of 25 mm. The bondline, 0.25 mm thick was controlled using 1% by weight of 250 μm ballantic glass beads mixed with the adhesive. In addition to standard single lap joints, one to three, 3 mm diameter holes, were drilled through the cured lap joint specimens to increase the degradation rate of the adhesive due to increased exposure to moisture. These holes were placed in the central low stress area of the joint overlap confirmed by finite element modelling. The joints were immersed in distilled water for up to 42 days at three test temperatures, 25, 40 and 60°C.

The average failure load per unit width was calculated from five repeat tests at each specific time, temperature and selected number of holes. No allowance for the reduction of bonding area was made to the areas calculated for the drilled specimens. A representation of a typical three hole perforated lap joint can be seen in Figure 1.

8 RESULTS AND DISCUSSION

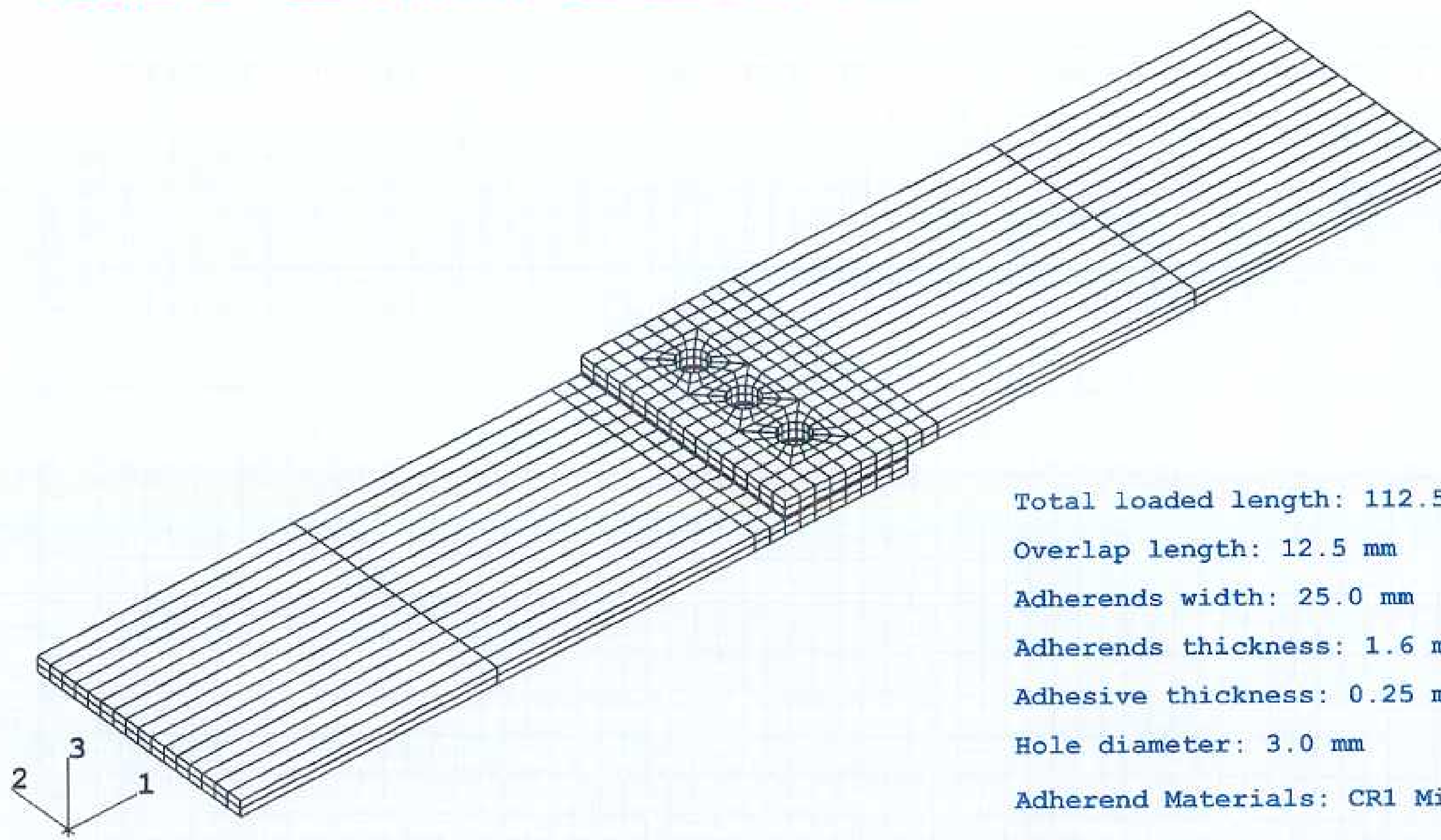
The average failure load values were analysed using a full factorial array for 0, 7, 14, 21 and 42 days using the Microsoft Excel V7 spreadsheet program. Table 5 shows the full matrix of tests including; factors, levels, interactions and the resultant failure data

Following this analysis, a number of hypotheses were tested.

Can valid data be predicted for intermediate time periods i.e. 3 days; and

2) Can subsets of data give a representative picture for the system.

FIGURE 1 PERFORATED SINGLE-LAP JOINT



Total loaded length: 112.5 mm

Overlap length: 12.5 mm

Adherends width: 25.0 mm

Adherends thickness: 1.6 mm

Adhesive thickness: 0.25 mm

Hole diameter: 3.0 mm

Adherend Materials: CR1 Mild Steel

Adhesive Material: AV119 Epoxy

	A	B	C	Interactions: A x B	Interactions: A x C	Interactions: B x C	
Run	Temp	No. Holes	Time	Temp x No Holes	Temp x Time	No Holes x Time	Failure Load N/mm
1	1	1	1	1	1	1	337
2	1	1	2	1	2	2	272
3	1	1	3	1	3	3	235
4	1	1	4	1	4	4	245
5	1	1	5	1	5	5	244
6	1	2	1	2	1	2	301
7	1	2	2	2	2	2	258
8	1	2	3	2	3	3	231
9	1	2	4	2	4	4	263
10	1	2	5	2	5	5	235
11	1	3	1	3	1	3	301
12	1	3	2	3	2	3	259
13	1	3	3	3	3	3	217
14	1	3	4	3	4	4	265
15	1	3	5	3	5	5	245
16	1	4	1	4	1	4	304
17	1	4	2	4	2	4	260
18	1	4	3	4	3	4	231
19	1	4	4	4	4	4	245
20	1	4	5	4	5	5	266
21	2	1	1	2	2	1	337
22	2	1	2	2	2	2	232
23	2	1	3	2	3	3	219
24	2	1	4	2	4	4	197
25	2	1	5	2	5	5	213
26	2	2	1	2	2	2	301
27	2	2	2	2	2	2	229
28	2	2	3	2	3	3	205
29	2	2	4	2	4	4	207
30	2	2	5	2	5	5	216
31	2	3	1	3	2	3	301
32	2	3	2	3	2	3	243
33	2	3	3	3	3	3	240
34	2	3	4	3	4	4	210
35	2	3	5	3	5	5	210
36	2	4	1	4	2	4	304
37	2	4	2	4	2	4	227
38	2	4	3	4	3	4	207
39	2	4	4	4	4	4	204
40	2	4	5	4	5	5	191
41	3	1	1	3	3	1	337
42	3	1	2	3	3	2	222
43	3	1	3	3	3	3	210
44	3	1	4	3	4	4	177
45	3	1	5	3	5	5	305
46	3	2	1	3	3	2	301
47	3	2	2	3	3	2	216
48	3	2	3	3	3	3	183
49	3	2	4	3	4	4	151
50	3	2	5	3	5	5	283
51	3	3	1	3	3	3	301
52	3	3	2	3	3	3	213
53	3	3	3	3	3	3	189
54	3	3	4	3	4	4	174
55	3	3	5	3	5	5	256
56	3	4	1	4	3	4	304
57	3	4	2	4	3	4	212
58	3	4	3	4	3	4	181
59	3	4	4	4	4	4	167
60	3	4	5	4	5	5	242

Legend

Average experimental value = 242.N/mm

Temperature (^{o}C)	Level	Holes	Level	Time (Days)	Level
25	1	0	1	0	1
40	2	1	2	7	2
60	3	2	3	14	3
		3	4	21	4
				42	5

Table 5:Full Factorial Matrix of Durability Study of AV119/CR1 steel lap joints.

9 ANALYSIS

Predicted values for data at 3 days at the three test temperatures and the requisite number of holes were calculated from the three constitutive equations which were derived from the full experimental matrix. The coefficients of these equations are given in Table 6. The three linear regression graphs showing the effect of the main experimental factors, time, the number of holes and temperature on the failure load per unit area are shown in Figures 2a, 2b and 2c.

Factor	Coefficient	Intercept
Number of Holes	-4.45	249.00
Temperature	-1.61	300.00
Time	-1.83	259.23

Table 6: Linear regression coefficients for full factorial durability study.

These are:

Number of holes

Failure load (N/mm) = (-4.45 x number of holes) + 249 (1)

Temperature

Failure load = (-1.61 x temperature) + 300.00 (2)

and

Time = (-1.83 x time) + 259.23 (3)

Which for three days Equation (3) is

Equation 3 = -1.83 x 3 + 259.23 = 253.74 N/mm

The predicted failure load can be calculated from the three constitutive equations using the grand average performance (GAP) value from the full factorial experiment as shown by equation 4.

For this experiment the GAP was 242 N/mm.

Failure strength = GAP + (No Holes- GAP) + (Temp- GAP) + (Time- GAP) (4)
Equation (1) Equation (2) Equation (3)

The results from this analysis are summarised in Table 4 and a comparison with measured experimental data is shown in Figure 3.

Figure 2a:Linear regression fit for number of holes vs failure load

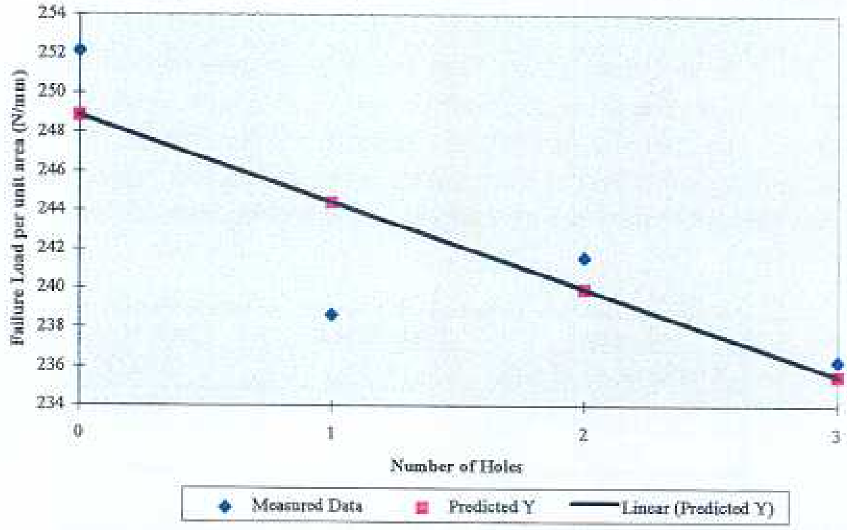


Figure 2b:Temperature vs Failure load-Linear regression line

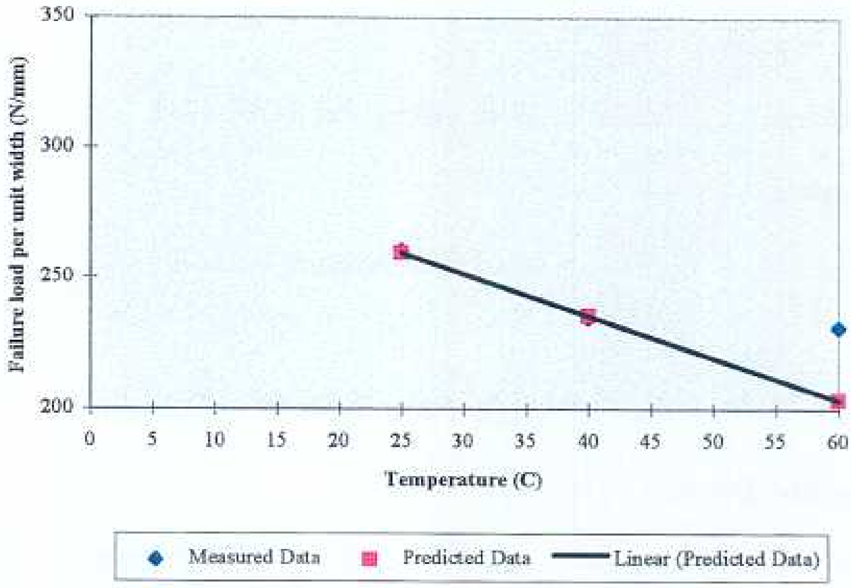


Figure 2c:Time-Linear regression Plot

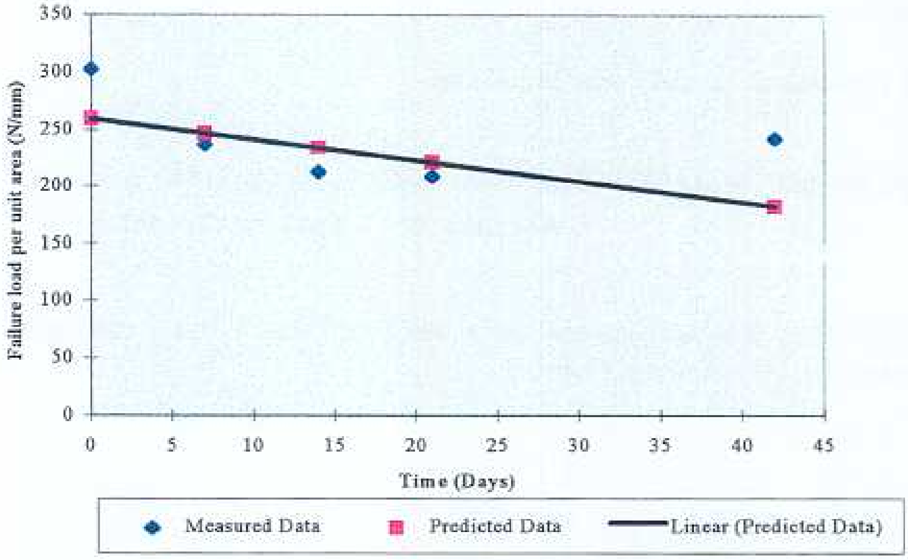
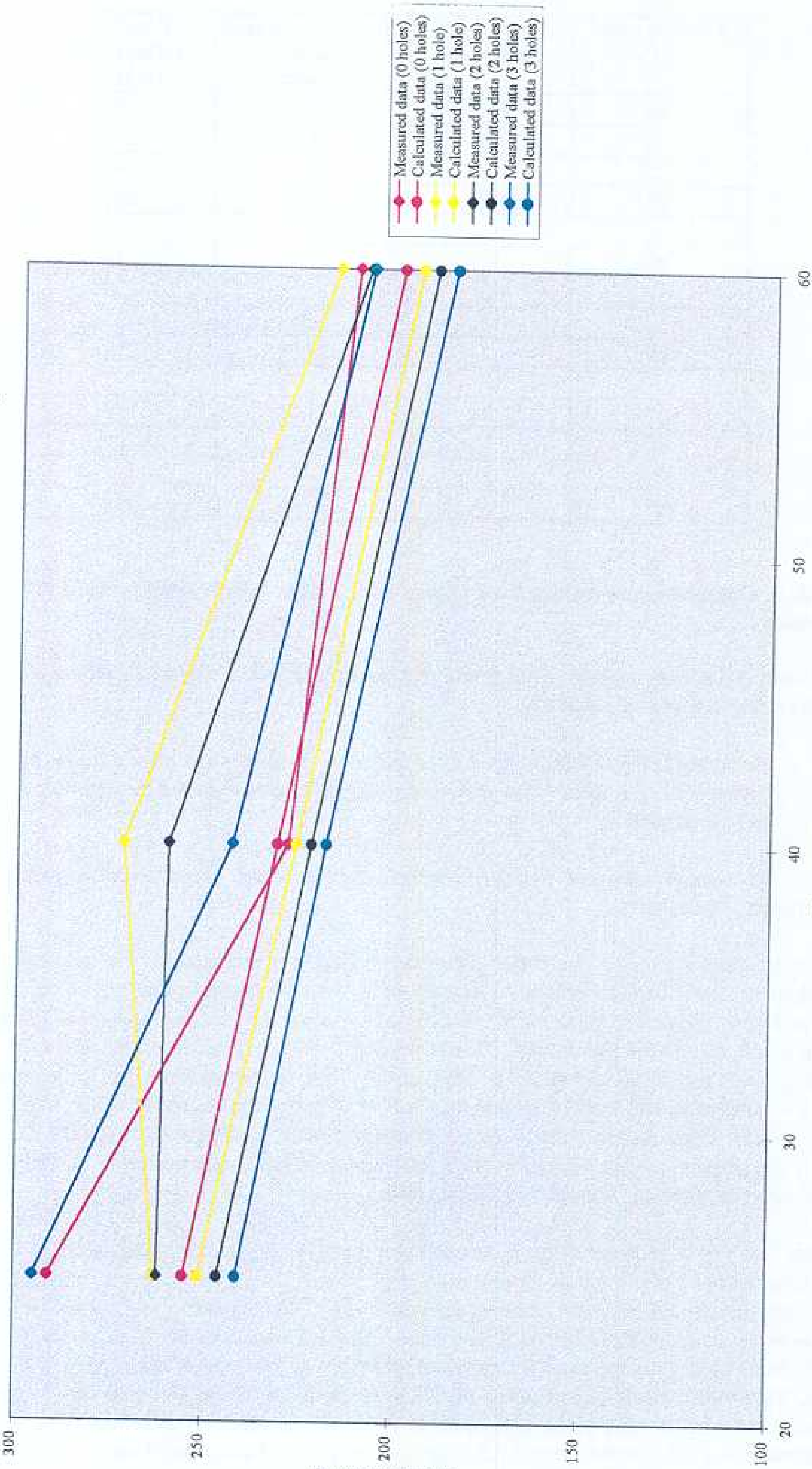


Figure 3: Comparison of measured and calculated values for failure loads at 3 days



Temperature (°C)	Number of Holes	Measured Failure load (N/mm)	Predicted failure load (N/mm)
25	0	291	255
25	1	263	251
25	2	262	246
25	3	295	241
40	0	228	231
40	1	272	226
40	2	260	222
40	3	243	218
60	0	211	199
60	1	216	194
60	2	208	190
60	3	207	185

Table 6: Calculation of failure load values after 3 days using coefficients of full factorial equation.

The data in Table 6, in combination with the data presented in Figure 2a indicate that for the main factors acting independently:

i) the number of holes introduced after the initial hole does not have a major effect on the failure load; i.e. there is no accelerated degradation due to the penetration of moisture into the adhesive.

ii) the temperature and the time factors seem to have the greatest influence on the experimental parameters.

The understanding of the interaction between the factors is essential for the development of a reliable accelerated ageing regime. The interaction between the main factors can be assessed by use of factor interaction parameters. Figures 4 to 6 show the average interaction effects of the three combinations of parameters. These average values can be resolved into their separate setting levels for all combinations of interaction Thus for temperature and time, temperature and the number of holes and time and the number of holes, the degree of factor interaction can be qualified. These factor interactions are shown in Figure 7 - Interaction between Temperature and Time, Figure 8 - Interaction between the number of holes and temperature, and Figure 9 - Interaction between the number of holes and time.

Figure 7 shows an increase in the failure load for the 60°C experimental data after 21 days. This increase could be due to be an increase in the plasticisation of the adhesive within the bulk of the joint, thereby relieving the stress at the joint ends. This increase in failure load is confirmed by work reported recently by AEA Harwell[5]. This increase after 21 days at 60 °C makes it difficult to model the system and the chart indicates an interaction between temperature and time. However there is no indication of any increase in the failure load at lower temperatures. To confirm whether this effect will occur at lower temperatures or at a faster rate at elevated temperatures, further experimental data needs to be collected at extended time periods.

Figure 4:Average Interaction Temperature x Time

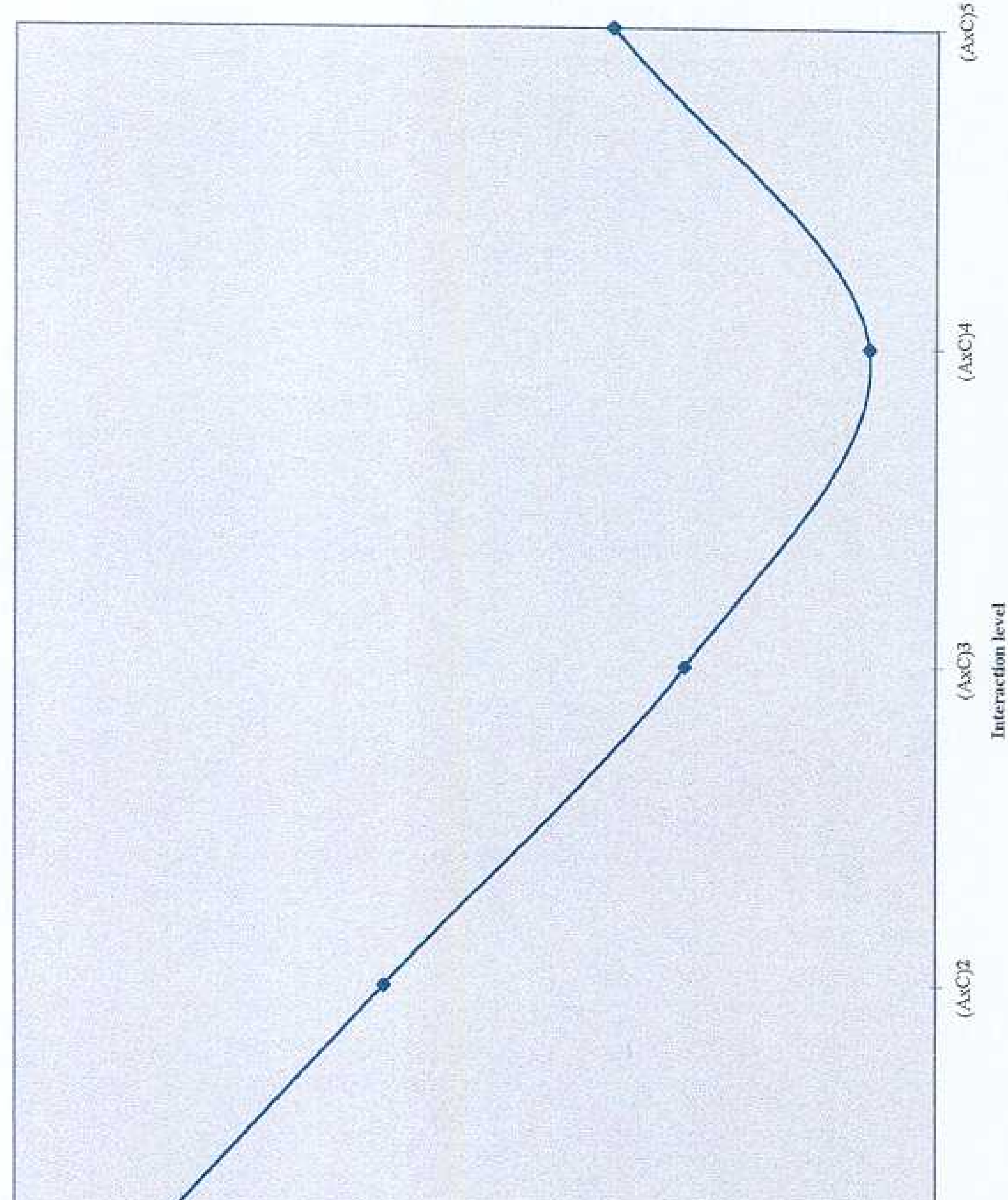


Figure 5: Average Interaction Temperature x No. Holes

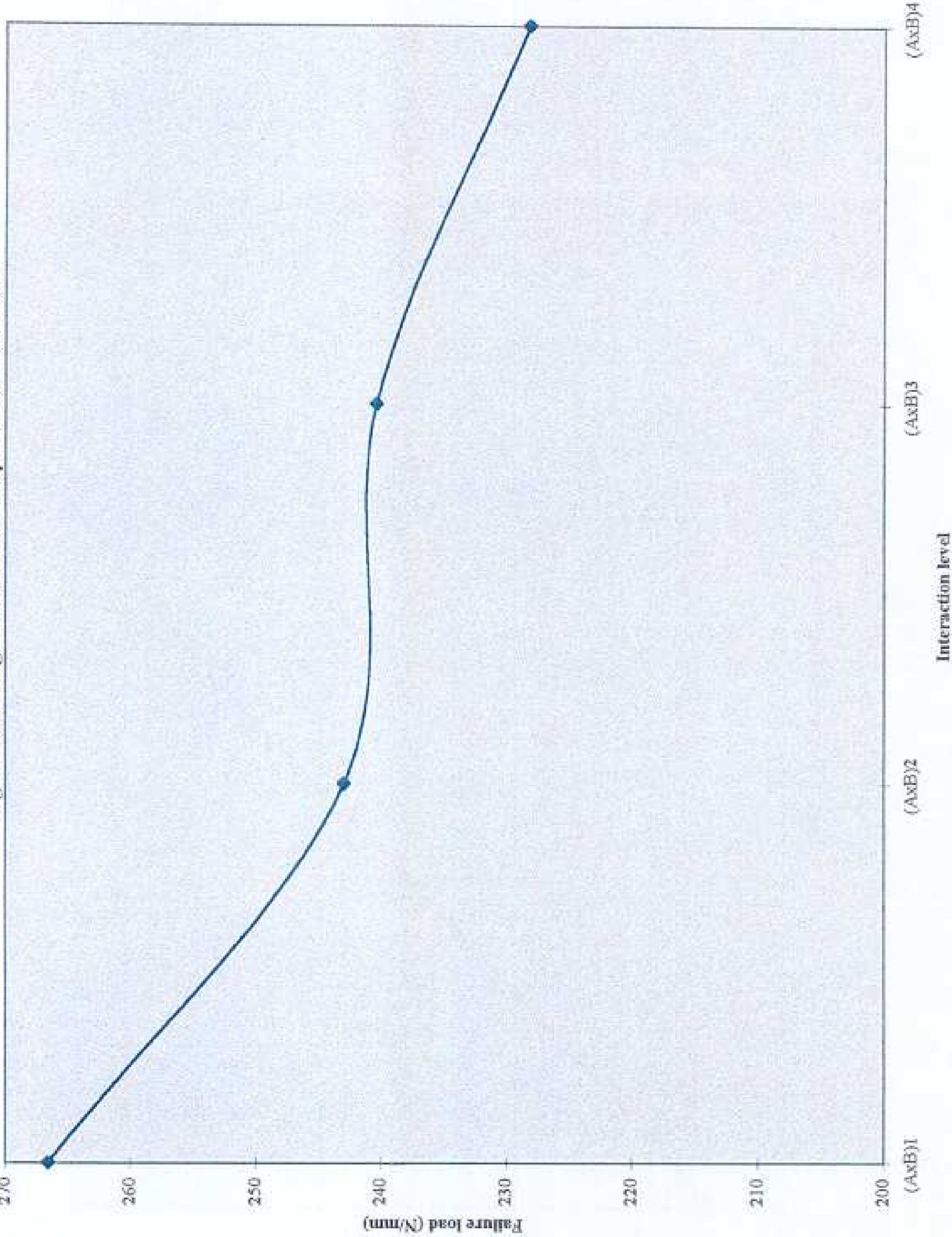


Figure 6: Average Interaction No. Holes x Time

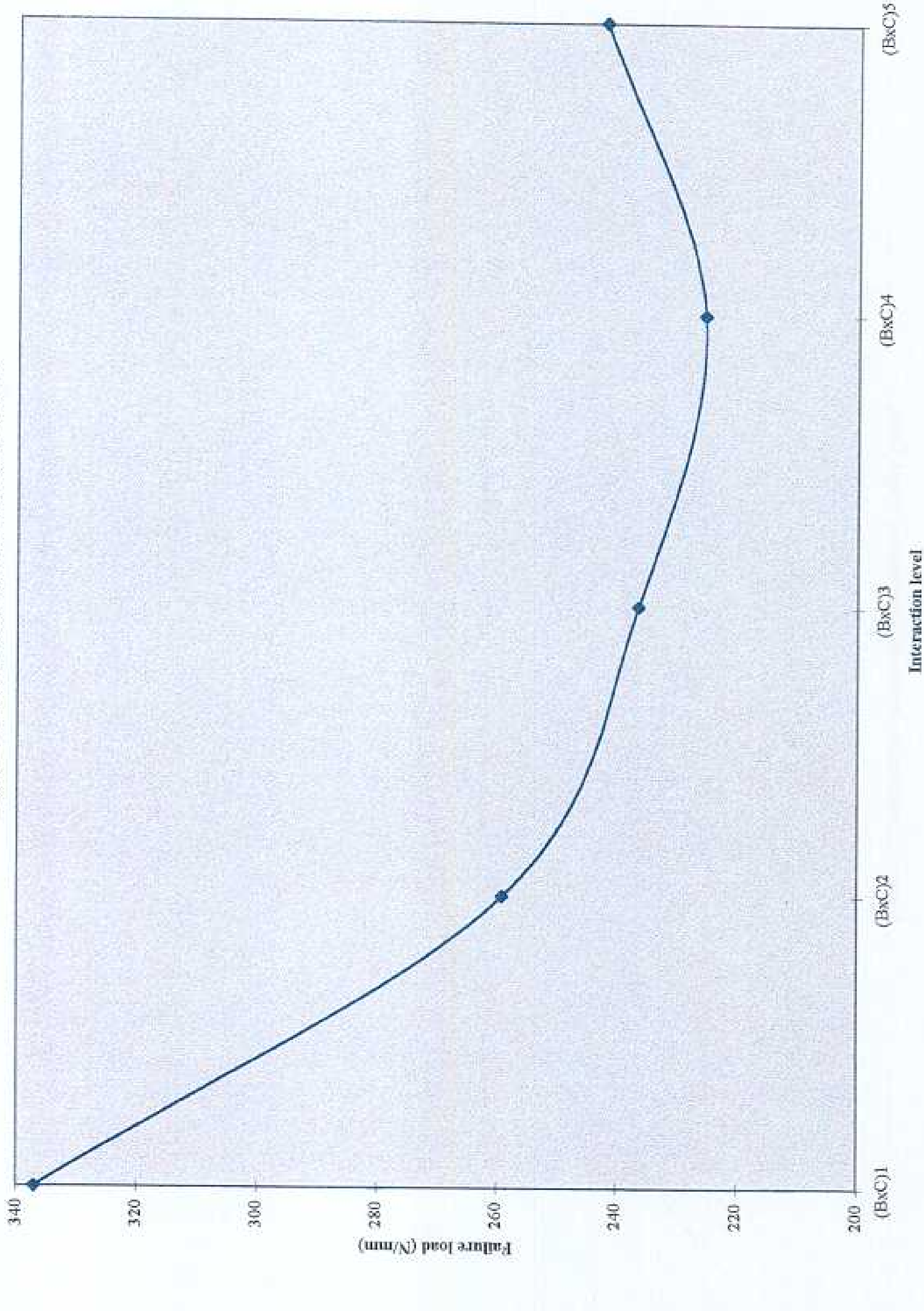


Figure 7:Interaction between Temperature and Time

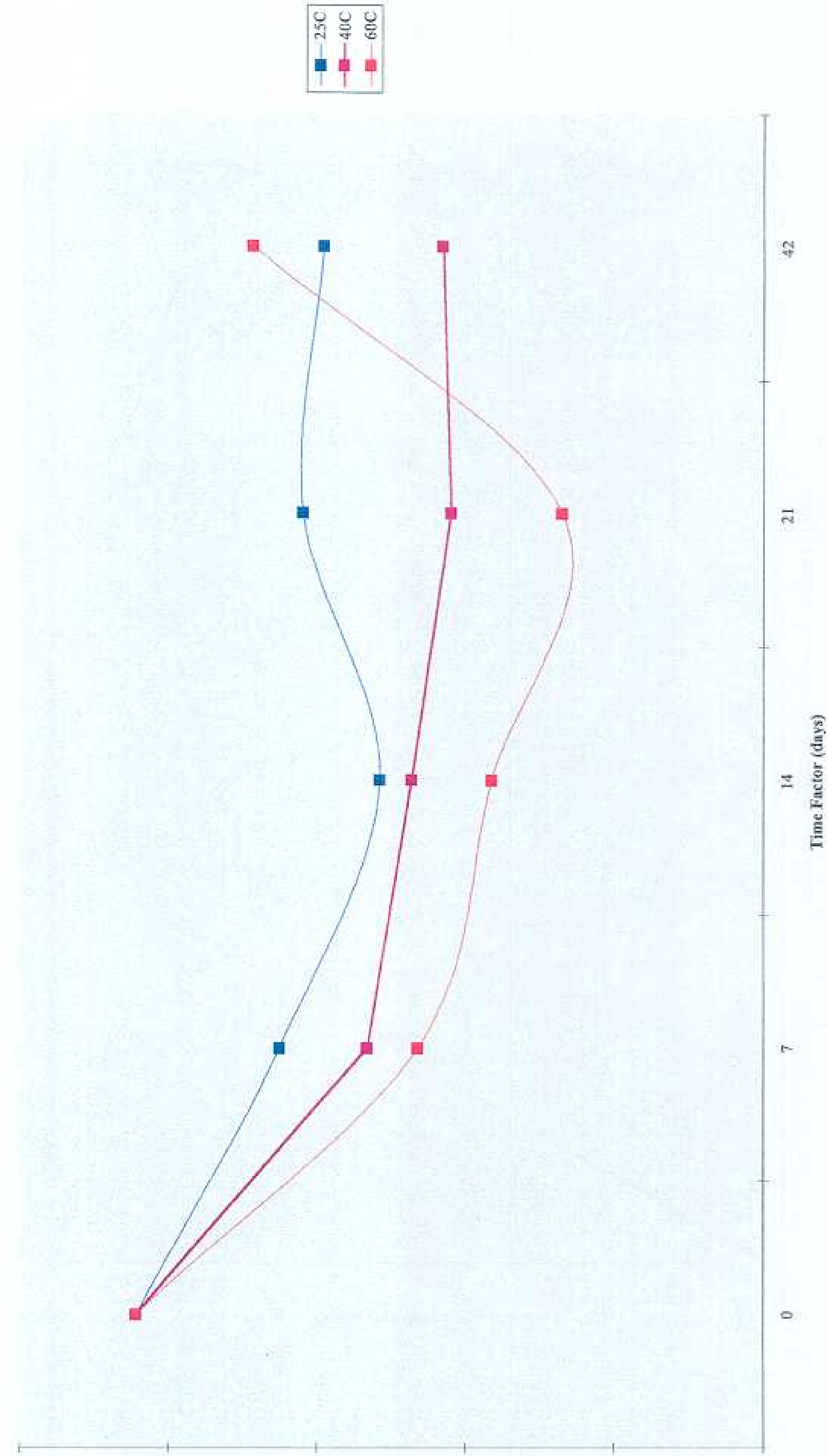


Figure 8:Interaction between Temperature and Number of Holes

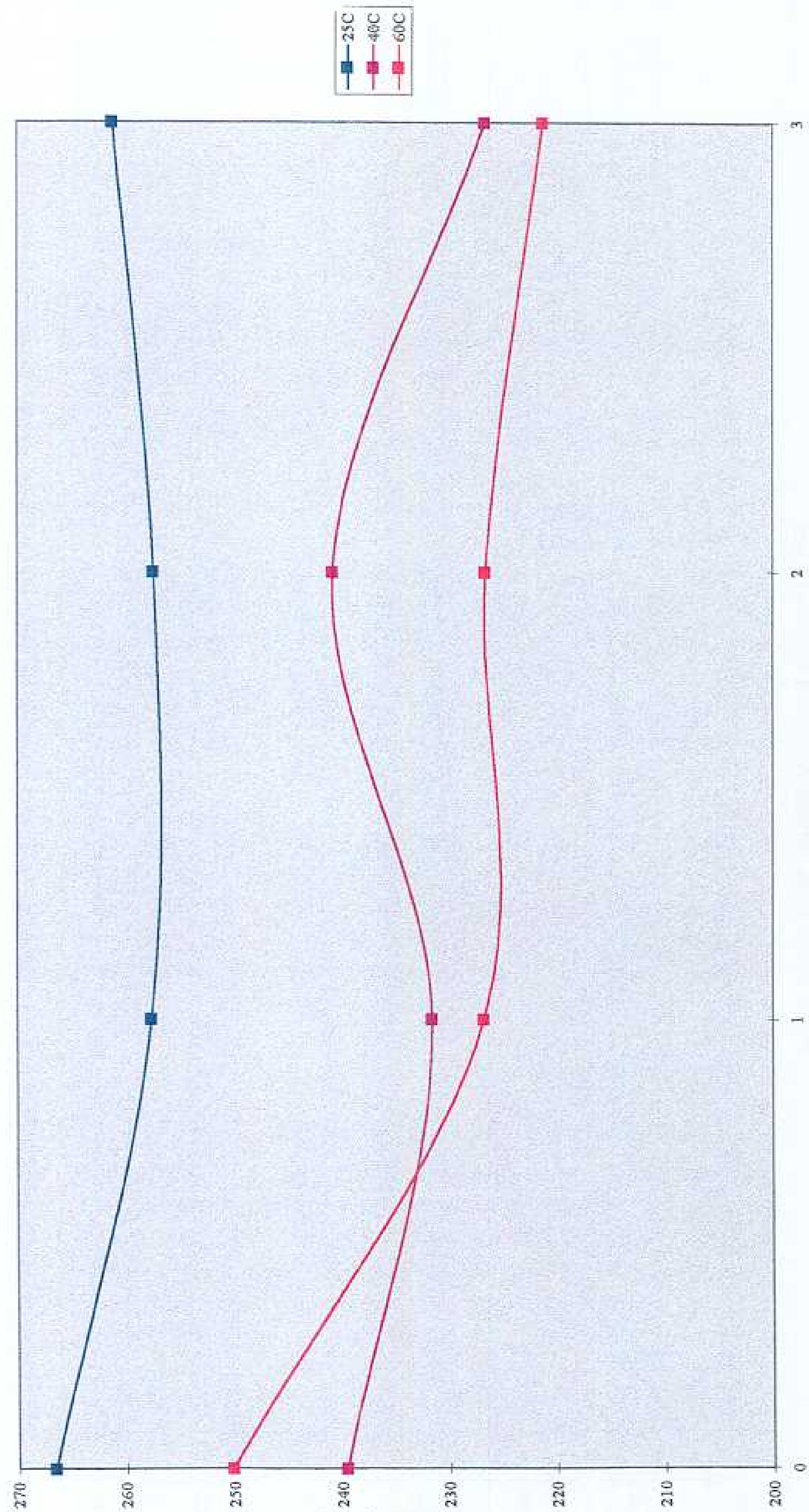


Figure 9: Interaction between Number of Holes and Time

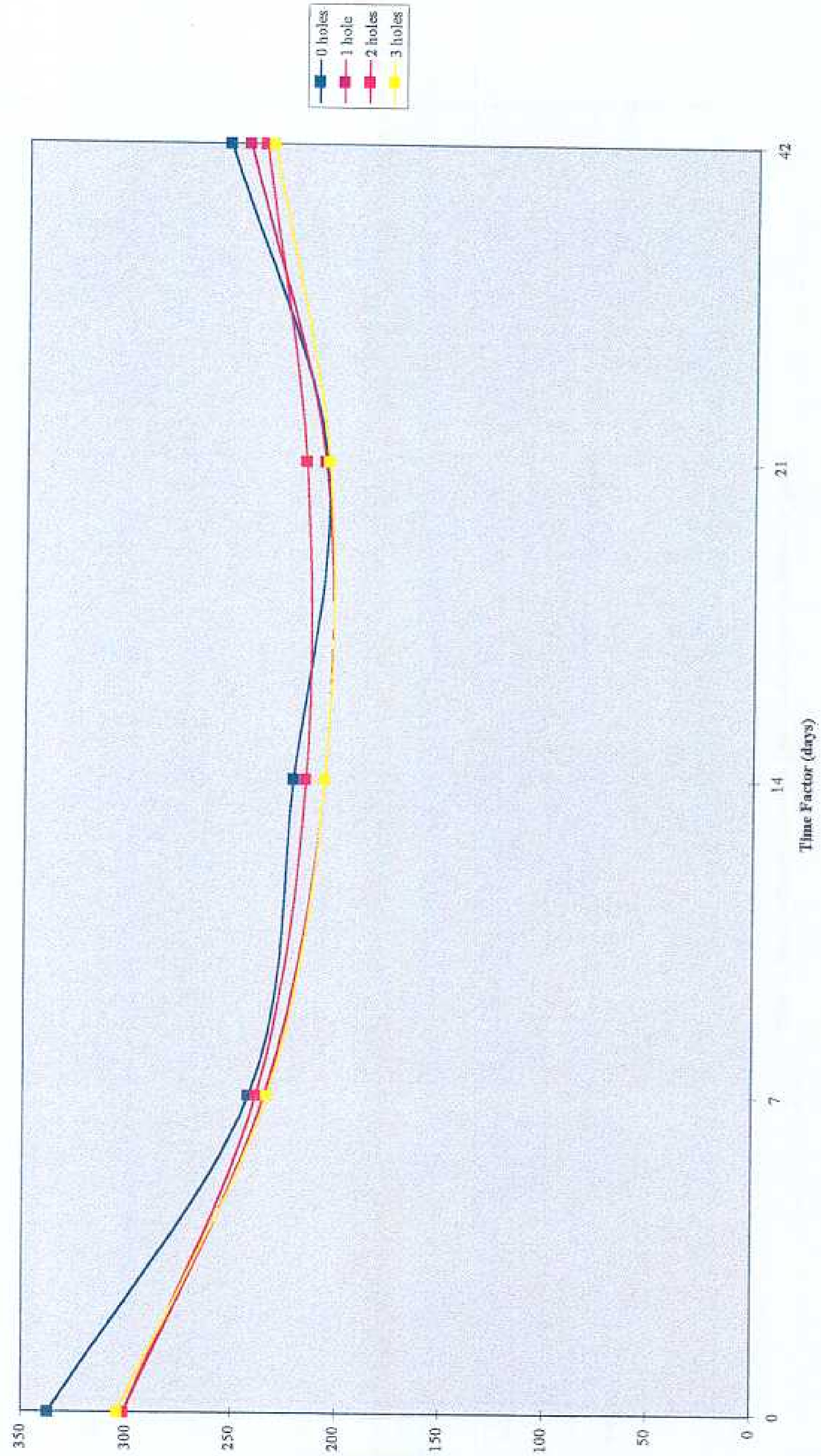


Figure 8 indicates that there is minimal interaction between the number of holes and temperature, within experimental error. Figure 9 indicates that the remaining interaction between the number of holes and time is not subject to any interaction. The data for the lap joints is not normalised. That is to say that the area removed by the holes has not been taken into account when calculating the failure load per unit width. The physical effect of perforating the lap joint can be seen from the change in failure load from time zero for an unperforated joint compared to the very similar failure loads for perforated joints, Figure 9. It appears that the 3 mm diameter holes that are introduced to increase the rate of diffusion of moisture into the joint have minimal effect on the joint failure strength in the period of exposure examined. This is probably due to the placement of the holes which are in the unstressed area of the joint. It is found that the critical area for failure to occur in a lap joint is at stress concentrated areas which are at the corners of the joint. As the holes are relatively a large distance apart the effect of the holes is rapidly reduced after the initial hole is introduced into the system. This is shown by the change in the data in Figure 9 at zero time.

Tests which are currently being conducted on single lap joint specimens with 4 mm diameter holes are showing a significant ageing effect compared to the smaller 3 mm perforations.

The large increase in the failure load at 60°C and 21 days requires confirmation from longer term tests at 25 and 40°C to determine if this is valid as regards an accelerated effect. Experimentally this increase and subsequent decrease in failure load is confirmed by previous work[5].

10 ANALYSIS OF AN ADHESIVE LAP JOINT DURABILITY - CONCLUSIONS

This design of experiments study indicates;

i) the number of holes introduced after the initial hole does not have a major effect on the failure load; i.e. there is minimal accelerated degradation due to the enhanced penetration of moisture into the adhesive due to the presence of 3 mm diameter holes

ii) there is no reduction of the structural integrity with the introduction of more than one hole into the lap joint

iii) the temperature and time factors seem to have the greatest influence on the experimental parameters.

Confirmation of an accelerated test regime based on a time-temperature relationship would be realised from a series of parallel curves for each test temperature. Taking into consideration that there are some experimental anomalies which to be assessed by further experiments at longer times and elevated temperatures, the relationship between time and temperature indicates that these factors form the basis of an accelerated ageing test regime.

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APPENDIX 1

Development of Data Sets for The Evaluation of Design of Experiments Software Packages.

Martin Hall and Terry Twine. Xyratex Ltd. Havant.

1.0 FOREWORD

The performance of adhesive bonds is often considered to be too variable for all but the least demanding of applications or those where there is no alternative joining technology and the industry has sufficient expertise to assure adequate design margin (eg. aerospace). The variation seen is often due to lack of knowledge and control of critical variables in the joint manufacturing and testing processes. Such variation can be magnified by durability testing to a point where no statistically valid conclusions can be made even though significant time, effort and cost have usually been expended.

This report forms part of Milestone 2 in Project 3 of the 1996 - 1999 DTI initiated and funded MTS Adhesives Programme. Milestone 2 (Statistical Methods and Analytical Models) is to identify and verify statistical methods that could be suitable for the design of durability experiments and subsequent data analysis. The objective of the work detailed in this report was to develop a series of data sets of increasing complexity that could be used to evaluate a number of Design of Experiments software packages.

2.0 REPORT

The data sets were produced by mathematical modelling of results from a case study of steel plate bonding for bridge reinforcement that formed part of the DTI funded 1993 - 1996 Performance of Adhesive Joints programme (see ref 3.1).

This case study used a fractional factorial experimental matrix to investigate the effect of ten control factors, each at two levels, on the bond strength of steel to steel plates using two part epoxy adhesive systems. Analysis of the experimental results showed that five of the ten factors were found to have a significant effect on the bond strength, as follows:

Factor A	- Adhesive Type
Factor D	- Relative Humidity
Factor G	- Solvent Cleaning of the Steel Substrate
Factor	- Vacuum Cleaning of the Steel Substrate
Factor J	- Cure Time before Testing

The analysis derived constants that relate to the significance of each factor on the bond strength. These constants were then used to produce four data sets based on models of increasing complexity, as follows:

Model 1	- a simple exact model using only the most significant factor (J) with no variability.
Model 2	- a model that still only uses factor J but adds variability based on a normal distribution around the mean (the distribution is based on the variation found in the results from the case study).
Model 3	- a more complex model using all the significant factors (A, D, G, and J) with no variability.

Model 4 - As per Model 3 but with variability added.

The equations derived for the four models are given in Appendix 1. From these equations data sets were calculated and are shown in Appendix 2 together with the experimental matrix design. For comparison purposes analysis of these data sets by the AGSS software package used at Xyratex is also included in Appendix 2.

It should be noted that the experimental matrix design applied to these models was from the AGSS software package which used the first 10 columns of a 15 column/ 16 run matrix. This matrix is a classic design but the order of the columns does vary in different reference tomes (see Appendix 3). Clearly the order might vary across different software packages so when comparing these packages it is important to force the same order to the matrix design for a fair comparison of the analysis capabilities. This is particularly necessary for models and 4 where variability has been introduced.

3.0 REFERENCES

3.1 Hurley & Gibbs DTI MTS Adhesives Project 5, Task 2, Report 8: Steel Plate Bonding

3.2 Taguchi Methods - Orthogonal Arrays and Linear Graphs American Supplier Institute

3.3 Montgomery Design and Analysis of Experiments Wiley

3.4 Grove & Davis Engineering Quality & Experimental Design Longman Scientific & Technical

3.5 Box, Hunter & Hunter Statistics for Experimenters Wiley

APPENDIX 1

EQUATIONS USED TO MODEL FOUR DATA SETS FOR EVALUATION OF DESIGN OF EXPERIMENTS SOFTWARE PACKAGES:

MODEL 1: Factor J only, no variability

The generic equation for the models is:

$Y = \upsilon + \alpha J$

where Y is the bond pull-off force, υ is the average, α is a constant related to the effect of factor J, and J is either -1 or +1 depending on level setting 1 or 2 used in the experiment (re the model matrices supplied, level 1 = -1 and level 2 = +1). For Models 3 & 4 there are unique constants that relate to the other factors incorporated into the equations (ie. for A, D, G and I, in addition to J).

The equation with values for Model 1 is:

Y = 4.251 - 1.225J

MODEL 2: Factor J only, with variability.

Y = 4.251 - 1.225J + N(0,0.7)

where N(0,0.7) indicates a random error component distributed as a normal distribution with mean offset of 0, and a standard deviation of 0.7.

MODEL 3: Factors A, D, G, and J, no variability

Y = 4.251 - 0.466A - 0.374D - 0.308G - 0.761I - 1.225J

MODEL 4: Factors A, D, G, and J, with variability

Y = 4.251 - 0.466A - 0.374D - 0.308G - 0.761I - 1.225J + N(0,0.7)

APPENDIX 2

DATA SETS BASED ON THE MATHEMATICAL MODELS SHOWN IN APPENDIX 1 AND AGSS ANALYSIS OF THESE DATA SETS

MODEL 1: Factor J only, no variability.

FACTOR LEVEL MATRIX

RUN	A	B	C	D	E	F	G	H	I	J	DATA
1	1	1	1	1	1	1	1	1	1	1	5.476
2	1	1	1	2	2	1	2	1	2	1	5.476
3	1	1	2	1	2	2	1	1	2	2	3.026
4	1	1	2	2	1	2	2	1	1	2	3.026
5	1	2	1	1	2	2	2	2	1	1	5.476
6	1	2	1	2	1	2	1	2	2	1	5.476
7	1	2	2	1	1	1	2	2	2	2	3.026
8	1	2	2	2	2	1	1	2	1	2	3.026
9	2	1	1	1	2	2	2	2	2	2	3.026
10	2	1	1	2	1	2	1	2	1	2	3.026
11	2	1	2	1	1	1	2	2	1	1	5.476
12	2	1	2	2	2	1	1	2	2	1	5.476
13	2	2	1	1	1	1	1	1	2	2	3.026
14	2	2	1	2	2	1	2	1	1	2	3.026
15	2	2	2	1	2	2	1	1	1	1	5.476
16	2	2	2	2	1	2	2	1	2	1	5.476

AGSS ANALYSIS OF MODEL 1

TABLE OF COEFFICIENTS

16 OBSERVATIONS R-SQUARED = 1 STANDARD ERROR = 0

11 VARIABLES ADJ R-SQUARED = 1

EFFECT	ESTIMATE	STD ERR	T STAT	SIG LEVEL	0.95 CONFIDENCE LIMITS LOWER	UPPER
MEAN	4.251	0	INF	0	4.251	4.251
A	0	0		0	0	0
B	0	0		0	0	0
C	0	0		0	0	0
D	0	0		0	0	0
E	0	0		0	0	0
F	0	0		0	0	0
G	0	0		0	0	0
H	0	0		0	0	0
	0	0		0	0	0
J	-2.45	0		0	-2.45	-2.45

A small value of significance level, such as less than .01, suggests a significant effect. A relatively large value, such as greater than .2, gives no evidence of a significant effect. When many significance tests are performed, the significance levels should be viewed in context as a few of them can be expected to be small due to chance alone.

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	SIG LEVEL
A	1	0	0	INF	0
B	1	0	0	INF	0
C	1	0	0	INF	0
D	1	0	0	INF	0
E	1	0	0	INF	0
F	1	0	0	INF	0
G	1	0	0	INF	0
H	1	0	0	INF	0
	1	0	0	INF	0
J	1	24.010	24.010	INF	0
ERROR	5	0	0		
TOTAL	15	24.010	1.6007		

A small value of significance level, such as less than .01, suggests a significant effect. A relatively large value, such as greater than .2, gives no evidence of a significant effect. When many significance tests are performed, the significance levels should be viewed in context as a few of them can be expected to be small due to chance alone.

MODEL 2: Factor J only, with variability.

FACTOR LEVEL MATRIX

RUN	A	B	C	D	E	F	G	H	I	J	DATA
1	1	1	1	1	1	1	1	1	1	1	6.769
2	1	1	1	2	2	1	2	1	2	1	5.086
3	1	1	2	1	2	2	1	1	2	2	2.159
4	1	1	2	2	1	2	2	1	1	2	3.409
5	1	2	1	1	2	2	2	2	1	1	6.667
6	1	2	1	2	1	2	1	2	2	1	
7	1	2	2	1	1	1	2	2	2	2	2.421
8	1	2	2	2	2	1	1	2	1	2	2.733
9	2	1	1	1	2	2	2	2	2	2	2.464
10	2	1	1	2	1	2	1	2	1	2	3.376
11	2	1	2	1	1	1	2	2	1		
12	2	1	2	2	2	1	1	2	2	1	
13	2	2	1	1	1	1	1	1	2	2	3.289
14	2	2	1	2	2	1	2	1	1	2	3.597
15	2	2	2	1	2	2	1	1	1	1	5.362
16	2	2	2	2	1	2	2	1	2	1	4.934

AGSS ANALYSIS OF MODEL 2

TABLE OF COEFFICIENTS

16 OBSERVATIONS R-SQUARED = 0.974 STANDARD ERROR = 0.45724

11 VARIABLES ADJ R-SQUARED = 0.922

					0.95 CONFIDENCE LIMITS	
EFFECT	ESTIMATE	STD ERR	T STAT	SIG LEVEL	LOWER	UPPER
MEAN	4.3459	0.11431	38.019	2.3719E-7	4.0521	4.6397
A	-0.39657	0.22862	-1.7346	1.4333E-1	-0.98424	0.1911
B	0.33642	0.22862	1.4715	2.0112E-1	-0.25125	0.92409
C	-0.89762	0.22862	-3.9263	1.1112E-2	-1.4853	-0.30995
D	0.067011	0.22862	0.29311	7.8121E-1	-0.52066	0.65468
E	-0.47754	0.22862	-2.0888	9.1040E-2	-1.0652	0.11014
F	0.1783	0.22862	0.7799	4.7074E-1	-0.40937	0.76597
G	-0.20509	0.22862	-0.89707	4.1079E-1	-0.79276	0.38259
H	0.040871	0.22862	0.17877	8.6513E-1	-0.5468	0.62854
	-0.62877	0.22862	-0.7503	4.0297E-2	-1.2164	-0.041095
J	-2.8302	0.22862	-12.38	6.0935E-5	-3.4179	-2.2426

A small value of significance level, such as less than .01, suggests a significant effect. A relatively large value, such as greater than .2, gives no evidence of a significant effect. When many significance tests are performed, the significance levels should be viewed in context as a few of them can be expected to be small due to chance alone.

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	SIG LEVEL
A	1	0.62907	0.62907	3.0089	0.14333
B	1	0.45271	0.45271	2.1654	0.20112
C	1	3.2229	3.2229	15.416	0.011112
D	1	0.017962	0.017962	0.085915	0.78121
E	1	0.91216	0.91216	4.363	0.09104
F	1	0.12716	0.12716	0.60824	0.47074
G	1	0.16824	0.16824	0.80473	0.41079
H	1	0.0066818	0.0066818	0.03196	0.86513
	1	1.5814	1.5814	7.564	0.040297
J	1	32.041	32.041	153.26	0.000060935
ERROR	5	1.0453	0.20907		
TOTAL	15	40.205	2.6803		

A small value of significance level, such as less than .01, suggests a significant effect. A relatively large value, such as greater than .2, gives no evidence of a significant effect. When many significance tests are performed, the significance levels should be viewed in context as a few of them can be expected to be small due to chance alone.

MODEL 3: Factors A, D, G, I and J, no variability.

FACTOR LEVEL MATRIX

RUN	A	B	C	D	E	F	G	H	I	J	DATA
1	1	1	1	1	1	1	1	1	1	1	7.385
2	1	1	1	2	2	1	2	1	2	1	4.499
3	1	1	2	1	2	2	1	1	2	2	3.413
4	1	1	2	2	1	2	2	1	1	2	3.571
5	1	2	1	1	2	2	2	2	1	1	6.769
6	1	2	1	2	1	2	1	2	2	1	5.115
7	1	2	2	1	1	1	2	2	2	2	
8	1	2	2	2	2	1	1	2	1	2	4.187
9	2	1	1	1	2	2	2	2	2	2	1.865
10	2	1	1	2	1	2	1	2	1	2	3.255
11	2	1	2	1	1	1	2	2	1	1	5.837
12	2	1	2	2	2	1	1	2	2	1	4.183
13	2	2	1	1	1	1	1	1	2	2	
14	2	2	1	2	2	1	2	1	1	2	2.639
15	2	2	2	1	2	2	1	1	1	1	6.453
16	2	2	2	2	1	2	2	1	2	1	3.567

AGSS ANALYSIS OF MODEL 3

TABLE OF COEFFICIENTS

16 OBSERVATIONS R-SQUARED = 1 STANDARD ERROR = 0

11 VARIABLES ADJ R-SQUARED = 1

EFFECT	ESTIMATE	STD ERR	T STAT	SIG LEVEL	0.95 CONFIDENCE LIMITS LOWER	UPPER
MEAN	4.2510	0	INF.	0	4.251	4.251
A	-0.932	0	INF	0	-0.932	-0.932
B	0	0			0	0
C	0	0			0	0
D	-0.748	0	INF	0	-0.748	-0.748
E	0	0	INF	0	0	0
F	0	0			0	0
G	-0.616	0	INF	0	-0.616	-0.616
H	0	0			0	0
	-1.5220	0	INF	0	-1.522	-1.522
J	-2.4500	0	INF	0	-2.45	-2.45

A small value of significance level, such as less than .01, suggests a significant effect. A relatively large value, such as greater than .2, gives no evidence of a significant effect. When many significance tests are performed, the significance levels should be viewed in context as a few of them can be expected to be small due to chance alone.

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	SIG LEVEL
A	1	3.4745	3.4745	INF	0
B	1	0	0	INF	0
C	1	0	0	INF	0
D	1	2.2380	2.2380	INF	0
E	1	0	0	INF	0
F	1	0	0	INF	0
G	1	1.5178	1.5178	INF	0
H	1	0	0	INF	0
	1	9.2659	9.2659	INF	0
J	1	24.010	24.0101	INF	0
ERROR	5	0	0		
TOTAL	15	40.506	2.7004		

A small value of significance level, such as less than .01, suggests a significant effect. A relatively large value, such as greater than .2, gives no evidence of a significant effect. When many significance tests are performed, the significance levels should be viewed in context as a few of them can be expected to be small due to chance alone.

MODEL 4: Factors A, D, G, and J, with variability.

FACTOR LEVEL MATRIX

RUN	A	B	C	D	E	F	G	H	I	J	DATA
1	1	1	1	1	1	1	1	1	1	1	8.678
2	1	1	1	2	2	1	2	1	2	1	4.109
3	1	1	2	1	2	2	1	1	2	2	2.546
4	1	1	2	2	1	2	2	1	1	2	3.954
5	1	2	1	1	2	2	2	2	1	1	7.96
6	1	2	1	2	1	2	1	2	2	1	6.749
7	1	2	2	1	1	1	2	2	2	2	2.192
8	1	2	2	2	2	1	1	2	1	2	3.894
9	2	1	1	1	2	2	2	2	2	2	1.303
10	2	1	1	2	1	2	1	2	1	2	3.605
11	2	1	2	1	1	1	2	2	1	1	5.731
12	2	1	2	2	2	1	1	2	2	1	3.497
13	2	2	1	1	1	1	1	1	2	2	2.744
14	2	2	1	2	2	1	2	1	1	2	3.21
15	2	2	2	1	2	2	1	1	1	1	6.339
16	2	2	2	2	1	2	2	1	2	1	3.025

AGSS ANALYSIS OF MODEL 4

TABLE OF COEFFICIENTS

16 OBSERVATIONS R-SQUARED = 0.98461 STANDARD ERROR = 0.45724

11 VARIABLES ADJ R-SQUARED = 0.95383

EFFECT	ESTIMATE	STD ERR	T STAT	SIG LEVEL	0.95 CONFIDENCE LIMITS LOWER	UPPER
MEAN	4.3459	0.11431	38.019	2.3719E-7	4.0521	4.6397
A	-1.3286	0.22862	-5.8113	2.1290E-3	-1.9162	-0.7409
B	0.33642	0.22862	1.4715	2.0112E-1	-0.25125	0.92409
C	-0.89762	0.22862	-3.9263	1.1112E-2	-1.4853	-0.30995
D	-0.68099	0.22862	-2.9787	3.0846E-2	-1.2687	-0.093316
E	-0.47754	0.22862	-2.0888	9.1040E-2	-1.0652	0.11014
F	0.1783	0.22862	0.7799	4.7074E-1	-0.40937	0.76597
G	-0.82109	0.22862	-3.5915	1.5683E-2	-1.4088	-0.23341
H	0.040871	0.22862	0.17877	8.6513E-1	-0.5468	0.62854
I	-2.1508	0.22862	-9.4076	2.2893E-4	-2.7384	-1.5631
J	-2.8302	0.22862	-12.38	6.0935E-5	-3.4179	-2.2426

A small value of significance level, such as less than .01, suggests a significant effect. A relatively large value, such as greater than .2, gives no evidence of a significant effect. When many significance tests are performed, the significance levels should be viewed in context as a few of them can be expected to be small due to chance alone.

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	SIG LEVEL
A	1	7.0604	7.0604	33.771	0.002129
B	1	0.45271	0.45271	2.1654	0.20112
C	1	3.2229	3.2229	15.416	0.011112
D	1	1.855	1.855	8.8727	0.030846
E	1	0.91216	0.91216	4.363	0.09104
F	1	0.12716	0.12716	0.60824	0.47074
G	1	2.6967	2.6967	12.899	0.015683
H	1	0.0066818	0.0066818	0.03196	0.86513
	1	18.503	18.503	88.504	0.00022893
J	1	32.041	32.041	153.26	0.000060935
ERROR	5	1.0453	0.20907		
TOTAL	15	67.923	4.5282		

A small value of significance level, such as less than .01, suggests a significant effect. A relatively large value, such as greater than .2, gives no evidence of a significant effect. When many significance tests are performed, the significance levels should be viewed in context as a few of them can be expected to be small due to chance alone.

APPENDIX 3

COMPARISON OF 15 FACTOR / 16 RUN EXPERIMENTAL MATRIX DESIGNS

AGSS FACTOR LEVEL MATRIX

Run	A	B	C	D	E	F	G	H	I	J	K	L	M	N	
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
2	1	1	1	2	2	1	2	1	2	1	2	2	1	2	
3	1	1	2	1	2	2	1	1	2	2	1	2	2	1	
4	1	1	2	2	1	2	2	1	1	2	2	1	2	2	
5	1	2	1	1	2	2	2	2	1	1	1	2	2	2	
6	1	2	1	2	1	2	1	2	2	1	2	1	2	1	
7	1	2	2	1	1	1	2	2	2	2	1	1	1	2	
8	1	2	2	2	2	1	1	2	1	2	2	2	1	1	
9	2	1	1	1	2	2	2	2	2	2	2	1	1	1	
10	2	1	1	2	1	2	1	2	1	2	1	2	1	2	
11	2	1	2	1	1	1	2	2	1	1	2	2	2	1	
12	2	1	2	2	2	1		2	2	1	1	1	2	2	
13	2	2	1	1	1	1	1	1	2	2	2	2	2	2	
14	2	2	1	2	2	1	2	1	1	2	1	1	2	1	
15	2	2	2	1	2	2	1	1	1	1	2	1	1	2	
16	2	2	2	2	1	2	2	1	2	1	1	2	1	1	
Tag	A	B	D	H	O	G	K	C	M	E	I	N	F	J	
Mon	H	D	B	A	O*	N	M	L*	K	J*	I*	G	F*	E*	C*
G&D	H	D	B	A	O*	N	M	L*	K	J*	I*	G	F*	E*	¬*
BHH	D	C	B	A	O*	N	M	J*	L	I*	G*	K	H*	F*	E*

The experimental matrix shown above is the design from the AGSS software package used by Xyratex. The organisation of the columns (A - O) in the AGSS matrix is compared against designs from other classic references, as follows:

- Tag - Taguchi; $L_{16}(2^{15})$ Matrix (see ref 3.2)
- Mon - Montgomery; Table 9-9, Contrast Constants for the 2^4 Design (see ref 3.3)
- G&D - Grove & Davies; Table 3.2, Fifteen Contrasts for the Data (see ref 3.4)
- BHH - Box, Hunter & Hunter; Table 10.7, Signs for Calculating Effects for a 2^4 Factorial (see ref 3.5).

NB. * indicates that the column labelling for the factor/level is reversed (ie. 1 is 2 & 2 is

APPENDIX 2

Statistical Methods and Analytical Models.

Case Study: Steel Plate Bonding.

Kathy Tully and Abayomi Olusanya.
NPL

Statistical Methods an Analytical Models

Qualitek 4

Analysis Of Variance (ANOVA)

	Factors	DOF	Sums Of Squares	Variance	F-Ratio	Pure Sum	Percent
3	Resin to Hardener	1	0.000	0.000	0.714	0.000	0.000
4	Mix Humidity	1	-0.001	-0.001	-1.429	0.000	0.000
5	Open Time to Join	1	-0.001	-0.001	-1.429	0.000	0.000
7	Degreasing of Ste	1	-0.001	-0.001	-1.429	0.000	0.000
9	Cure Time to Test	1	-0.001	-0.001	-1.429	0.000	0.000
10	Steel Surface Con	1	24.009	24.009	528,789.614	24.009	99.999
	Other/Error	5	-0.001	-0.001			0.001
	Total:	15	24.009				100.000%

Optimum Condition and Performance

	Factors	Level Desc.	Level	Contribution
3	Resin to Hardener	Specified	1	0.000
4	Mix Humidity	10% Humid	1	-0.001
5	Open Time to Join	Minimum P	1	-0.001
7	Degreasing of Ste	No Solven	1	-0.001
9	Cure Time to Test	1 day	1	-0.001
10	Steel Surface Con	Wet	1	1.224

Total Contribution From All Factors...	1.224
Current Grand Average Of Performance...	4.250
Expected Result At Optimum Condition...	5.475

Analysis Of Variance (ANOVA)

	Factors	DOF	Sums Of Squares	Variance	F-Ratio	Pure Sum	Percent
1	Adhesive Type	1	0.628	0.628	3.003	0.419	1.043
2	Adhesive Applicat	1	0.452	0.452	2.160	0.242	0.604
3	Resin to Hardener	1	3.222	3.222	15.390	3.012	7.494
4	Mix Humidity	1	0.017	0.017	0.084	0.000	0.000
5	Open Time to Join	1	0.912	0.912	4.356	0.702	1.748
6	Cure Temperature	1	0.127	0.127	0.606	0.000	0.000
7	Degreasing of Stc	1	0.168	0.168	0.802	0.000	0.000
8	Vacuum Cleaning o	1	0.006	0.006	0.031	0.000	0.000
9	Cure Time to Test	1	1.581	1.581	7.553	1.371	3.412
10	Steel Surface Con	1	32.035	32.035	153.022	31.826	79.172
	Other/Error	**5**	**1.046**	**0.209**			**6.527**
	Total:	**15**	**40.198**				**100.000%**

Optimum Condition and Performance

	Factors	Level Desc.	Level	Contribution
1	Adhesive Type	Normal Gr	1	0.198
2	Adhesive Applicat	Applied as Bl	2	0.168
3	Resin to Hardener	Specified	1	0.448
4	Mix Humidity	70% Humidity	2	0.033
5	Open Time to Join	Minimum P	1	0.238
6	Cure Temperature	Rec Min - 5 C	2	0.089
7	Degreasing of Ste	No Solven	1	0.102
8	Vacuum Cleaning o	Vacuum Cleane	2	0.020
9	Cure Time to Test	1 day	1	0.314
10	Steel Surface Con	Wet	1	1.414

Total Contribution From All Factors...	3.028
Current Grand Average Of Performance...	4.346
Expected Result At Optimum Condition...	7.374

Analysis Of Variance (ANOVA)

	Factors	DOF	Sums Of Squares	Variance	F-Ratio	Pure Sum	Percent
1	Adhesive Type	1	3.474	3.474	173,723.631	3.474	8.577
2	Adhesive Applicat	1	-0.001	-0.001	-0.507	0.000	0.000
3	Resin to Hardener	1	0.000	0.000	1.114	0.000	0.000
4	Mix Humidity	1	2.238	2.238	111,900.336	2.237	5.525
5	Open Time to Join	1	0.000	0.000	1.114	0.000	0.000
6	Cure Temperature	1	-0.001	-0.001	-0.507	0.000	0.000
7	Degreasing of Ste	1	1.517	1.517	75,890.736	1.517	3.747
8	Vacuum Cleaning o	1	-0.001	-0.001	-0.507	0.000	0.000
9	Cure Time to Test	1	9.265	9.265	463,295.237	9.265	22.875
10	Steel Surface Con	1	24.009	24.009	1,200,499.306	24.009	59.274
	Other/Error	**5**	**-0.001**	**-0.001**			**0.002**
	Total:	**15**	**40.506**				**100.000%**

Optimum Condition and Performance

	Factors	Level Desc.	Level	Contribution
1	Adhesive Type	Normal Gr	1	0.466
2	Adhesive Applicat	Levelled	1	-0.001
3	Resin to Hardener	Minus 10% of H	2	0.000
4	Mix Humidity	10% Humid	1	0.373
5	Open Time to Join	Minimum P	1	0.000
6	Cure Temperature	23 C	1	-0.001
7	Degreasing of Ste	No Solven	1	0.308
8	Vacuum Cleaning o	No Vacuum	1	-0.001
9	Cure Time to Test	1 day	1	0.760
10	Steel Surface Con	Wet	1	1.224

Total Contribution From All Factors...	3.134
Current Grand Average Of Performance...	4.250
Expected Result At Optimum Condition...	7.384

Analysis Of Variance (ANOVA)

	Factors	DOF	Sums Of Squares	Variance	F-Ratio	Pure Sum	Percent
1	Adhesive Type	1	7.059	7.059	33.723	6.850	10.086
2	Adhesive Applicat	1	0.452	0.452	2.160	0.242	0.357
3	Resin to Hardener	1	3.222	3.222	15.391	3.012	4.435
4	Mix Humidity	1	1.856	1.856	8.868	1.647	2.425
5	Open Time to Join	1	0.912	0.912	4.356	0.702	1.034
6	Cure Temperature	1	0.127	0.127	0.607	0.000	0.000
7	Degreasing of Ste	1	2.696	2.696	12.879	2.486	3.661
8	Vacuum Cleaning o	1	0.006	0.006	0.031	0.000	0.000
9	Cure Time to Test	1	18.502	18.502	88.387	18.293	26.934
10	Steel Surface Con	1	32.035	32.035	153.033	31.826	46.860
	Other/Error	5	1.046	0.209			4.208
	Total:	15	67.917				100.000%

Optimum Condition and Performance

	Factors	Level Desc.	Level	Contribution
1	Adhesive Type	Normal Gr	1	0.664
2	Adhesive Applicat	Applied as Bl	2	0.168
3	Resin to Hardener	Specified	1	0.448
4	Mix Humidity	10% Humid	1	0.340
5	Open Time to Join	Minimum P	1	0.238
6	Cure Temperature	Rec Min - 5 C	2	0.089
7	Degreasing of Ste	No Solven	1	0.410
8	Vacuum Cleaning o	Vacuum Cleane	2	0.020
9	Cure Time to Test	1 day	1	1.075
10	Steel Surface Con	Wet	1	1.415

Total Contribution From All Factors...	4.870
Current Grand Average Of Performance...	4.346
Expected Result At Optimum Condition...	9.216

Statistical Methods and Analytical Models

DOE Wisdom

DOE Wisdom Analysis of Variance

Dependent Variable:	Bond Strength
Number Runs(N):	16
Multiple R:	1.00000
Squared Multiple R:	1.00000
Adjusted Squared Multiple R:	1.00000
Standard Error of Estimate:	0.000000

Variable	Coefficient	Std Error	Tolerance	T	P(2 Tail)
Constant	4.25100	0.000000		*****	*****
A	0.000000	0.000000	1.000	*****	*****
B	0.000000	0.000000	1.000	*****	*****
-AB	0.000000	0.000000	1.000	*****	*****
C	0.000000	0.000000	1.000	*****	*****
-AC	0.000000	0.000000	1.000	*****	*****
-BC	0.000000	0.000000	1.000	*****	*****
F	0.000000	0.000000	1.000	*****	*****
D	0.000000	0.000000	1.000	*****	*****
-AD	0.000000	0.000000	1.000	*****	*****
-BD	0.000000	0.000000	1.000	*****	*****
G	0.000000	0.000000	1.000	*****	*****
J	-1.22500	0.000000	1.000	*****	*****
H	0.000000	0.000000	1.000	*****	*****
E	0.000000	0.000000	1.000	*****	*****
I	0.000000	0.000000	1.000	*****	*****

Source	Sum of Squares	DF	Mean Square	F Ratio	P
Regression	24.010000	15	1.6006667	*****	*****
Residual	0.00000000	0	0.00000000		

DOE Wisdom Prediction Equation

	Bond Strength	
	5.47600	
Constant	4.25100	
A	-4.44089e-016	-1.00000
B	-5.03070e-016	-1.00000
-AB	-2.84495e-016	-1.00000
C	-5.31693e-016	-1.00000
-AC	-5.02202e-016	-1.00000
-BC	-3.03577e-016	-1.00000
F	7.28584e-017	-1.00000
D	-2.44596e-016	-1.00000
-AD	-1.07553e-016	-1.00000
-BD	4.40620e-016	-1.00000
G	2.56739e-016	-1.00000
J	-1.22500	-1.00000
H	2.90566e-017	-1.00000
E	-3.46945e-016	-1.00000
I	-6.38595e-017	-1.00000

DOE Wisdom Prediction Equation

	Bond Strength	
	3.02600	
Constant	4.25100	
A	-4.44089e-016	1.00000
B	-5.03070e-016	1.00000
-AB	-2.84495e-016	-1.00000
C	-5.31693e-016	1.00000
-AC	-5.02202e-016	-1.00000
-BC	-3.03577e-016	-1.00000
F	7.28584e-017	1.00000
D	-2.44596e-016	1.00000
-AD	-1.07553e-016	-1.00000
-BD	4.40620e-016	-1.00000
G	2.56739e-016	1.00000
J	-1.22500	1.00000
H	2.90566e-017	1.00000
E	-3.46945e-016	1.00000
I	-6.38595e-017	1.00000

DOE Wisdom Analysis of Means

Run	A	B	C	F	D	G	J	H	E	I
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	+	+	+	+	+	+
3	-	-	+	+	-	-	+	+	+	+
4	-	-	+	+	+	+	-	-	-	-
5	-	+	-	+	-	+	-	-	+	-
6	-	+	-	+	+	-	+	+	-	-
7	-	+	+	-	-	+	+	+	-	-
8	-	+	+	-	+	-	-	-	+	+
9	+	-	-	+	-	+	-	+	-	+
10	+	-	-	+	+	-	+	-	+	-
11	+	-	+	-	-	+	+	-	+	-
12	+	-	+	-	+	-	-	+	-	+
13	+	+	-	-	-	-	-	+	+	-
14	+	+	-	-	+	+	+	-	-	+
15	+	+	+	+	-	-	+	-	-	+
16	+	+	+	+	+	+	-	+	+	-

		A	B	C	F	D	G	J	H	E	I
Avg	Avg-	4.25100	4.25100	4.25100	4.25100	4.25100	4.25100	5.47600	4.25100	4.25100	4.25100
	Avg+	4.25100	4.25100	4.25100	4.25100	4.25100	4.25100	3.02600	4.25100	4.25100	4.25100
	Delta	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-2.45000	0.000000	0.000000	0.000000
	Delta/2	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-1.22500	0.000000	0.000000	0.000000
S	Avg-	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	Avg+	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	Delta	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	Delta/2	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ln S	Avg-	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233
	Avg+	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233
	Delta	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	Delta/2	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Bond Strength

Avg	S	ln S
5.47600	0.000000	-20.7233
3.02600	0.000000	-20.7233
3.02600	0.000000	-20.7233
5.47600	0.000000	-20.7233
5.47600	0.000000	-20.7233
3.02600	0.000000	-20.7233
3.02600	0.000000	-20.7233
5.47600	0.000000	-20.7233
5.47600	0.000000	-20.7233
3.02600	0.000000	-20.7233
3.02600	0.000000	-20.7233
5.47600	0.000000	-20.7233
5.47600	0.000000	-20.7233
3.02600	0.000000	-20.7233
3.02600	0.000000	-20.7233
5.47600	0.000000	-20.7233
4.25100	0.000000	-20.7233

DOE Wisdom Analysis of Variance

Dependent Variable:	Bond Strength
Number Runs(N):	16
Multiple R:	1.00000
Squared Multiple R:	1.00000
Adjusted Squared Multiple R:	1.00000
Standard Error of Estimate:	0.000000

Variable	Coefficient	Std Error	Tolerance	T	P(2 Tail)
Constant	4.34600	0.000000		*****	*****
A	-0.198250	0.000000	1.000	*****	*****
B	0.168125	0.000000	1.000	*****	*****
-AB	0.0203750	0.000000	1.000	*****	*****
C	-0.448750	0.000000	1.000	*****	*****
-AC	-0.190000	0.000000	1.000	*****	*****
-BC	0.202875	0.000000	1.000	*****	*****
F	0.0891250	0.000000	1.000	*****	*****
D	0.0333750	0.000000	1.000	*****	*****
-AD	0.00687500	0.000000	1.000	*****	*****
-BD	-0.0460000	0.000000	1.000	*****	*****
G	-0.102500	0.000000	1.000	*****	*****
J	-1.26088	0.000000	1.000	*****	*****
H	-0.314375	0.000000	1.000	*****	*****
E	-0.144250	0.000000	1.000	*****	*****
I	-0.238750	0.000000	1.000	*****	*****

Source	Sum of Squares	DF	Mean Square	F Ratio	P
Regression	34.156684	15	2.2771123	*****	*****
Residual	0.00000000	0	0.00000000		

DOE Wisdom Prediction Equation

	Bond Strength	
	6.76900	
Constant	4.34600	
A	-0.198250	-1.00000
B	0.168125	-1.00000
-AB	0.0203750	-1.00000
C	-0.448750	-1.00000
-AC	-0.190000	-1.00000
-BC	0.202875	-1.00000
F	0.0891250	-1.00000
D	0.0333750	-1.00000
-AD	0.00687500	-1.00000
-BD	-0.0460000	-1.00000
G	-0.102500	-1.00000
J	-1.26088	-1.00000
H	-0.314375	-1.00000
E	-0.144250	-1.00000
I	-0.238750	-1.00000

DOE Wisdom Prediction Equation

	Bond Strength	
	1.93475	
Constant	4.34600	
A	-0.198250	1.00000
B	0.168125	1.00000
-AB	0.0203750	-1.00000
C	-0.448750	1.00000
-AC	-0.190000	-1.00000
-BC	0.202875	-1.00000
F	0.0891250	1.00000
D	0.0333750	1.00000
-AD	0.00687500	-1.00000
-BD	-0.0460000	-1.00000
G	-0.102500	1.00000
J	-1.26088	1.00000
H	-0.314375	1.00000
E	-0.144250	1.00000
I	-0.238750	1.00000

DOE Wisdom Analysis of Means

	Run	A	B	C	F	D	G	J	H	E	I
	1	-	-	-	-	-	-	-	-	-	-
	2	-	-	-	-	+	+	+	+	+	+
	3	-	-	+	+	-	-	+	+	+	+
	4	-	-	+	+	+	+	-	-	-	-
	5	-	+	-	+	-	+	-	-	+	+
	6	-	+	-	+	+	-	+	+	-	-
	7	-	+	+	-	-	+	+	+	-	-
	8	-	+	+	-	+	-	-	-	+	+
	9	+	-	-	+	-	+	-	+	-	+
	10	+	-	-	+	+	-	+	-	+	-
	11	+	-	+	-	-	+	+	-	+	-
	12	+	-	+	-	+	-	-	+	-	+
	13	+	+	-	-	-	-	-	+	+	-
	14	+	+	-	-	+	+	+	-	-	+
	15	+	+	+	+	-	-	+	-	-	+
	16	+	+	+	+	+	+	-	+	+	-
Avg	Avg-	4.54425	4.17788	4.79475	4.25688	4.31263	4.44850	5.60687	4.66038	4.49025	4.58475
	Avg+	4.14775	4.51412	3.89725	4.43513	4.37938	4.24350	3.08512	4.03163	4.20175	4.10725
	Delta	-0.396500	0.336250	-0.897500	0.178250	0.0667500	-0.205000	-2.52175	-0.628750	-0.288500	-0.477500
	Delta/2	-0.198250	0.168125	-0.448750	0.0891250	0.0333750	-0.102500	-1.26088	-0.314375	-0.144250	-0.238750
S	Avg-	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	Avg+	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	Delta	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	Delta/2	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ln S	Avg-	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233
	Avg+	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233
	Delta	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	Delta/2	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Bond Strength

Avg	S	ln S
6.76900	0.000000	-20.7233
2.63600	0.000000	-20.7233
2.15900	0.000000	-20.7233
5.85900	0.000000	-20.7233
6.66700	0.000000	-20.7233
4.66000	0.000000	-20.7233
2.42100	0.000000	-20.7233
5.18300	0.000000	-20.7233
4.91400	0.000000	-20.7233
3.37600	0.000000	-20.7233
2.92000	0.000000	-20.7233
4.79000	0.000000	-20.7233
5.73900	0.000000	-20.7233
3.59700	0.000000	-20.7233
2.91200	0.000000	-20.7233
4.93400	0.000000	-20.7233
4.34600	0.000000	-20.7233

DOE Wisdom Analysis of Variance

Dependent Variable:	Bond Strength
Number Runs(N):	16
Multiple R:	1.00000
Squared Multiple R:	1.00000
Adjusted Squared Multiple R:	1.00000
Standard Error of Estimate:	0.000000

Variable	Coefficient	Std Error	Tolerance	T	P(2 Tail)
Constant	4.40413	0.000000		*****	*****
A	-0.619125	0.000000	1.000	*****	*****
B	-0.153125	0.000000	1.000	*****	*****
-AB	-0.153125	0.000000	1.000	*****	*****
C	0.153125	0.000000	1.000	*****	*****
-AC	0.153125	0.000000	1.000	*****	*****
-BC	0.153125	0.000000	1.000	*****	*****
F	0.153125	0.000000	1.000	*****	*****
D	-0.527125	0.000000	1.000	*****	*****
-AD	-0.153125	0.000000	1.000	*****	*****
-BD	-0.153125	0.000000	1.000	*****	*****
G	-0.461125	0.000000	1.000	*****	*****
J	-1.07187	0.000000	1.000	*****	*****
H	0.153125	0.000000	1.000	*****	*****
E	0.153125	0.000000	1.000	*****	*****
I	-0.607875	0.000000	1.000	*****	*****

Source	Sum of Squares	DF	Mean Square	F Ratio	P
Regression	42.027416	15	2.8018277	*****	*****
Residual	0.00000000	0	0.00000000		

DOE Wisdom Prediction Equation

	Bond Strength	
	7.38500	
Constant	4.40413	
A	-0.619125	-1.00000
B	-0.153125	-1.00000
-AB	-0.153125	-1.00000
C	0.153125	-1.00000
-AC	0.153125	-1.00000
-BC	0.153125	-1.00000
F	0.153125	-1.00000
D	-0.527125	-1.00000
-AD	-0.153125	-1.00000
-BD	-0.153125	-1.00000
G	-0.461125	-1.00000
J	-1.07187	-1.00000
H	0.153125	-1.00000
E	0.153125	-1.00000
I	-0.607875	-1.00000

DOE Wisdom Prediction Equation

	Bond Strength	
	1.72950	
Constant	4.40413	
A	-0.619125	1.00000
B	-0.153125	1.00000
-AB	-0.153125	-1.00000
C	0.153125	1.00000
-AC	0.153125	-1.00000
-BC	0.153125	-1.00000
F	0.153125	1.00000
D	-0.527125	1.00000
-AD	-0.153125	-1.00000
-BD	-0.153125	-1.00000
G	-0.461125	1.00000
J	-1.07187	1.00000
H	0.153125	1.00000
E	0.153125	1.00000
I	-0.607875	1.00000

DOE Wisdom Analysis of Means

Run	A	B	C	F	D	G	J	H	E	I
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	+	+	+	+	+	+
3	-	-	+	+	-	-	+	+	+	+
4	-	-	+	+	+	+	-	-	-	-
5	-	+	-	+	-	+	-	-	+	+
6	-	+	-	+	+	-	+	+	-	-
7	-	+	+	-	-	+	+	+	-	-
8	-	+	+	-	+	-	-	-	+	+
9	+	-	-	+	-	+	-	+	-	+
10	+	-	-	+	+	-	+	-	+	-
11	+	-	+	-	-	+	+	-	+	-
12	+	-	+	-	+	-	-	+	-	+
13	+	+	-	-	-	-	-	+	+	-
14	+	+	-	-	+	+	+	-	-	+
15	+	+	+	+	-	-	+	-	-	+
16	+	+	+	+	+	+	-	+	+	-

		A	B	C	F	D	G	J	H	E	I
Avg	Avg-	5.02325	4.55725	4.25100	4.25100	4.93125	4.86525	5.47600	4.25100	4.25100	5.01200
	Avg+	3.78500	4.25100	4.55725	4.55725	3.87700	3.94300	3.33225	4.55725	4.55725	3.79625
	Delta	-1.23825	-0.306250	0.306250	0.306250	-1.05425	-0.922250	-2.14375	0.306250	0.306250	-1.21575
	Delta/2	-0.619125	-0.153125	0.153125	0.153125	-0.527125	-0.461125	-1.07188	0.153125	0.153125	-0.607875
S	Avg-	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	Avg+	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	Delta	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	Delta/2	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ln S	Avg-	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233
	Avg+	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233
	Delta	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	Delta/2	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Bond Strength

Avg	S	ln S
7.38500	0.000000	-20.7233
2.04900	0.000000	-20.7233
5.86300	0.000000	-20.7233
6.02100	0.000000	-20.7233
5.24700	0.000000	-20.7233
4.18700	0.000000	-20.7233
4.31900	0.000000	-20.7233
5.11500	0.000000	-20.7233
4.31500	0.000000	-20.7233
3.25500	0.000000	-20.7233
3.38700	0.000000	-20.7233
4.18300	0.000000	-20.7233
6.45300	0.000000	-20.7233
1.11700	0.000000	-20.7233
2.48100	0.000000	-20.7233
5.08900	0.000000	-20.7233
4.40413	0.000000	-20.7233

DOE Wisdom Analysis of Variance

Dependent Variable:	Bond Strength
Number Runs(N):	16
Multiple R:	1.00000
Squared Multiple R:	1.00000
Adjusted Squared Multiple R:	1.00000
Standard Error of Estimate:	0.000000

Variable	Coefficient	Std Error	Tolerance	T	P(2 Tail)
Constant	4.49913	0.000000		*****	*****
A	-0.817375	0.000000	1.000	*****	*****
B	0.0150000	0.000000	1.000	*****	*****
-AB	-0.132750	0.000000	1.000	*****	*****
C	-0.295625	0.000000	1.000	*****	*****
-AC	-0.0368750	0.000000	1.000	*****	*****
-BC	0.356000	0.000000	1.000	*****	*****
F	0.242250	0.000000	1.000	*****	*****
D	-0.493750	0.000000	1.000	*****	*****
-AD	-0.146250	0.000000	1.000	*****	*****
-BD	-0.199125	0.000000	1.000	*****	*****
G	-0.563625	0.000000	1.000	*****	*****
J	-1.10775	0.000000	1.000	*****	*****
H	-0.161250	0.000000	1.000	*****	*****
E	0.00887500	0.000000	1.000	*****	*****
I	-0.846625	0.000000	1.000	*****	*****

Source	Sum of Squares	DF	Mean Square	F Ratio	P
Regression	56.985852	15	3.7990568	*****	*****
Residual	0.00000000	0	0.00000000		

DOE Wisdom Prediction Equation

	Bond Strength	
	8.67800	
Constant	4.49913	
A	-0.817375	-1.00000
B	0.0150000	-1.00000
-AB	-0.132750	-1.00000
C	-0.295625	-1.00000
-AC	-0.0368750	-1.00000
-BC	0.356000	-1.00000
F	0.242250	-1.00000
D	-0.493750	-1.00000
-AD	-0.146250	-1.00000
-BD	-0.199125	-1.00000
G	-0.563625	-1.00000
J	-1.10775	-1.00000
H	-0.161250	-1.00000
E	0.00887500	-1.00000
I	-0.846625	-1.00000

DOE Wisdom Prediction Equation

	Bond Strength	
	0.638250	
Constant	4.49913	
A	-0.817375	1.00000
B	0.0150000	1.00000
-AB	-0.132750	-1.00000
C	-0.295625	1.00000
-AC	-0.0368750	-1.00000
-BC	0.356000	-1.00000
F	0.242250	1.00000
D	-0.493750	1.00000
-AD	-0.146250	-1.00000
-BD	-0.199125	-1.00000
G	-0.563625	1.00000
J	-1.10775	1.00000
H	-0.161250	1.00000
E	0.00887500	1.00000
I	-0.846625	1.00000

DOE Wisdom Analysis of Means

	Run	A	B	C	F	D	G	J	H	E	I
	1	-	-	-	-	-	-	-	-	-	-
	2	-	-	-	-	+	+	+	+	+	+
	3	-	-	+	+	-	-	+	+	+	+
	4	-	-	+	+	+	+	-	-	-	-
	5	-	+	-	+	-	+	-	-	+	+
	6	-	+	-	+	+	-	+	+	-	-
	7	-	+	+	-	-	+	+	+	-	-
	8	-	+	+	-	+	-	-	-	+	+
	9	+	-	-	+	-	+	-	+	-	+
	10	+	-	-	+	+	-	-	-	+	-
	11	+	-	+	-	-	+	+	-	+	-
	12	+	-	+	-	+	-	-	+	-	+
	13	+	+	-	-	-	-	-	+	+	-
	14	+	+	-	-	+	+	+	-	-	+
	15	+	+	+	+	-	-	+	-	-	+
	16	+	+	+	+	+	+	-	+	+	-
Avg	Avg-	5.02325	4.55725	4.25100	4.25100	4.93125	4.86525	5.47600	4.25100	4.25100	5.01200
	Avg+	3.78500	4.25100	4.55725	4.55725	3.87700	3.94300	3.33225	4.55725	4.55725	3.79625
	Delta	-1.23825	-0.306250	0.306250	0.306250	-1.05425	-0.922250	-2.14375	0.306250	0.306250	-1.21575
	Delta/2	-0.619125	-0.153125	0.153125	0.153125	-0.527125	-0.461125	-1.07188	0.153125	0.153125	-0.607875
S	Avg-	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	Avg+	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	Delta	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	Delta/2	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ln S	Avg-	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233
	Avg+	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233	-20.7233
	Delta	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	Delta/2	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Bond Strength		
Avg	S	ln S
7.38500	0.000000	-20.7233
2.04900	0.000000	-20.7233
5.86300	0.000000	-20.7233
6.02100	0.000000	-20.7233
5.24700	0.000000	-20.7233
4.18700	0.000000	-20.7233
4.31900	0.000000	-20.7233
5.11500	0.000000	-20.7233
4.31500	0.000000	-20.7233
3.25500	0.000000	-20.7233
3.38700	0.000000	-20.7233
4.18300	0.000000	-20.7233
6.45300	0.000000	-20.7233
1.11700	0.000000	-20.7233
2.48100	0.000000	-20.7233
5.08900	0.000000	-20.7233
4.40413	0.000000	-20.7233

Statistical Methods
Analytical Models

DOE-PC IV

MODEL 1

ANOVA SUMMARY..........>..........>..........>..........> ...>..........>...........>..........>.....

	Sum of Squares (Partial SS)	df	Mean Square	F - ratio	Level of Significance
Model					
Main Factors - Linear	24.01	10	2.401	Undefin	Undefin
Error	0	5	Undefin		
Total	24.01	15	Undefin		

ANOVA SOURCES of VARIATION..........>..........>..........>..........>..........>....

Source	Sum of Squares	df	F - Ratio	Significance
1000000000 Adhesive	0	1	Undefin	Undefin
0100000000 Adhesive	0	1	Undefin	Undefin
0010000000 Resin to	0	1	Undefin	Undefin
0001000000 Mix Humid	0	1	Undefin	Undefin
0000100000 Open Time	0	1	Undefin	Undefin
0000010000 Cure Temp	0	1	Undefin	Undefin
0000001000 Degreasin	0	1	Undefin	Undefin
0000000100 Vacuum Cl	0	1	Undefin	Undefin
0000000010 Cure Time	0	1	Undefin	Undefin
0000000001 Steel Sur	24.01	1	Undefin	Undefin

REGRESSION SUMMARY

Source	Sum of Squares	df	Mean Square
Regression Model			
Factors	24.01	10	2.401
Residuals - Total	0	5	0
Lack of Fit	0	5	0
Pure Error	0	0	0
Totals	24.01	15	

Statistics	F - Ratio	Probability
MS-Factors/MS-Residuals	Undefined	Undefined
MS-Factors/MS-Pure Error	Undefined	Undefined
MS-Lack of Fit/MS-Pure Error	Undefined	Undefined

Fitted Response	Standard Error	df
Bond Strength	Undefined	5

Coefficient of Determination		Subgroups	
R-squared	1	Number	16
R-squared, adjusted	Undefined	Average Size	1
Coefficient of Variation	Undefined	Minimum Size	1
		Maximum Size	1

FITTED PARAMETERS..........>..........>.........>..........>..........>..........>. ..>..........>..........>....

Source / Parameter	Levels	Coefficient	Standard Error	Transmitted Variance	Sum of Squares (Partial SS)	t-Ratio	Level of Significance
0000000000 Mean	0	5.476	Undefined	Undefined	Undefined	Undefined	Undefined
1000000000 Adhesiv	2	0	Undefined	Undefined	Undefined	Undefined	Undefined
0100000000 Adhesiv	2	0	Undefined	Undefined	Undefined	Undefined	Undefined
0010000000 Resin t	2	0	Undefined	Undefined	Undefined	Undefined	Undefined
0001000000 Mix Hum	2	0	Undefined	Undefined	Undefined	Undefined	Undefined
0000100000 Open Ti	2	0	Undefined	Undefined	Undefined	Undefined	Undefined
0000010000 Cure Te	2	0	Undefined	Undefined	Undefined	Undefined	Undefined
0000001000 Degreas	2	0	Undefined	Undefined	Undefined	Undefined	Undefined
0000000100 Vacuum	2	0	Undefined	Undefined	Undefined	Undefined	Undefined
0000000010 Cure Ti	2	0	Undefined	Undefined	Undefined	Undefined	Undefined
0000000001 Steel S	2	-2.45	Undefined	Undefined	Undefined	Undefined	Undefined

No correlation exists among the parameters.

MODEL 2

ANOVA SUMMARY

	Sum of Squares (Partial SS)	df	Mean Square	F - ratio	Level of Significance
Model					
Main Factors - Linear	39.152	10	3.915	18.703	0.996
Error	1.047	5	0.209		
Total	40.198	15	Undefin		

ANOVA SOURCES of VARIATION

Source	Sum of Squares	df	F - Ratio	Significance
1000000000 Adhesive	0.629	1	3.004	0.858
0100000000 Adhesive	0.452	1	2.16	0.8
0010000000 Resin to	3.222		15.392	0.988
0001000000 Mix Humid	0.018	1	0.085	Undefin
0000100000 Open Time	0.912	1	4.357	0.91
0000010000 Cure Temp	0.127	1	0.607	Undefin
0000001000 Degreasin	0.168	1	0.803	Undefin
0000000100 Vacuum Cl	0.007	1	0.032	Undefin
0000000010 Cure Time	1.581	1	7.554	0.96
0000000001 Steel Sur	32.036	1	153.036	1

REGRESSION SUMMARY

Source	Sum of Squares	df	Mean Square
Regression Model			
Factors	39.152	10	3.915
Residuals - Total	1.047	5	0.209
Lack of Fit	1.047	5	0.209
Pure Error	0	0	0
Totals	40.198	15	

Statistics	F - Ratio	Probability
MS-Factors/MS-Residual:	18.703	0.996
MS-Factors/MS-Pure Errc	Undefined	Undefined
MS-Lack of Fit/MS-Pure l	Undefined	Undefined

Fitted Response	Standard Error	df
Bond Strength	0.458	5

Coefficient of Determination		Subgroups	
R-squared	0.974	Number	16
R-squared, adjusted	0.922	Average Size	
Coefficient of Variation	0.01	Minimum Size	
		Maximum Size	

FITTED PARAMETERS

Source / Parameter	Levels	Coefficient	Standard Error	Transmitted Variance	Sum of Squares (Partial SS)	t-Ratio	Level of Significance
0000000000 Mean	0	6.753	0.379	0	0	0	0
1000000000 Adhesiv	2	-0.396	0.229	0.1	0.629	-1.733	0.856
0100000000 Adhesiv	2	0.336	0.229	0.1	0.452	1.47	0.798
0010000000 Resin t	2	-0.898	0.229	0.1	3.222	-3.923	0.989
0001000000 Mix Hum	2	0.067	0.229	0.1	0.018	0.292	0.218
0000100000 Open Ti	2	-0.478	0.229	0.1	0.912	-2.087	0.909
0000010000 Cure Te	2	0.178	0.229	0.1	0.127	0.779	0.529
0000001000 Degreas	2	-0.205	0.229	0.1	0.168	-0.896	0.589
0000000100 Vacuum	2	0.041	0.229	0.1	0.007	0.178	0.134
0000000010 Cure Ti	2	-0.629	0.229	0.1	1.581	-2.748	0.96
0000000001 Steel S	2	-2.83	0.229	0.1	32.036	-12.371	1

No correlation exists among the parameters.

MODEL 3

ANOVA SUMMARY..........>..........>..........>..........>..........>..........>..........>..........>.....

	Sum of Squares (Partial SS)	df	Mean Square	F - ratio	Level of Significance
Model					
Main Factors - Linear	40.506	10	4.051	1.71E+31	
Error	0	5	0		
Total	40.506	15	Undefin		

ANOVA SOURCES of VARIATION..........>..........>..........>. .....>..........>.....

Source	Sum of Squares	df	F - Ratio	Significance
1000000000 Adhesive	3.474	1	1.47E+31	1
0100000000 Adhesive	0	1	0	Undefin
0010000000 Resin to	0	1	-0.521	Undefin
0001000000 Mix Humid	2.238	1	9.46E+30	1
0000100000 Open Time	0	1	0.156	Undefin
0000010000 Cure Temp	0	1	-0.521	Undefin
0000001000 Degreasin	1.518	1	6.41E+30	1
0000000100 Vacuum Cl	0	1	1.51	0.726
0000000010 Cure Time	9.266	1	3.92E+31	1
0000000001 Steel Sur	24.01	1	1.01E+32	1

REGRESSION SUMMARY

Source	Sum of Squares	df	Mean Square
Regression Model			
Factors	40.506	10	4.051
Residuals - Total	0	5	0
Lack of Fit	0	5	0
Pure Error	0	0	0
Totals	40.506	15	

Statistics	F - Ratio	Probability
MS-Factors/MS-Residuals	Undefined	Undefined
MS-Factors/MS-Pure Error	Undefined	Undefined
MS-Lack of Fit/MS-Pure Erro	Undefined	Undefined

Fitted Response	Standard Error	df
Bond Strength	Undefined	5

Coefficient of Determination		Subgroups	
R-squared	1	Number	16
R-squared, adjusted	Undefined	Average Siz	1
Coefficient of Variation	0	Minimum S	1
		Maximum S	1

FITTED PARAMETERS..........>..........>..........>..........>..........>..........>..........>..........>..........>.....

Source / Parameter	Levels	Coefficient	Standard Error	Transmitted Variance	Sum of Squares (Partial SS)	t-Ratio	Level of Significance
0000000000 Mean	0	7.385	Undefined	Undefined	Undefined	Undefined	Undefined
1000000000 Adhesiv	2	-0.932	Undefined	Undefined	Undefined	Undefined	Undefined
0100000000 Adhesiv	2	0	Undefined	Undefined	Undefined	Undefined	Undefined
0010000000 Resin t	2	0	Undefined	Undefined	Undefined	Undefined	Undefined
0001000000 Mix Hum	2	-0.748	Undefined	Undefined	Undefined	Undefined	Undefined
0000100000 Open Ti	2	0	Undefined	Undefined	Undefined	Undefined	Undefined
0000010000 Cure Te	2	0	Undefined	Undefined	Undefined	Undefined	Undefined
0000001000 Degreas	2	-0.616	Undefined	Undefined	Undefined	Undefined	Undefined
0000000100 Vacuum	2	0	Undefined	Undefined	Undefined	Undefined	Undefined
0000000010 Cure Ti	2	-1.522	Undefined	Undefined	Undefined	Undefined	Undefined
0000000001 Steel S	2	-2.45	Undefined	Undefined	Undefined	Undefined	Undefined

No correlation exists among the parameters.

MODEL 4

ANOVA SUMMARY.........>.........>.........>.........>.........>.........>..........>.........>.....

	Sum of Squares (Partial SS)	df	Mean Square	F - ratio	Level of Significance
Model					
Main Factors - Linear	66.871	10	6.69E+00	31.945	0.999
Error	1.047	5	0.209		
Total	67.917	15	Undefin		

ANOVA SOURCES of VARIATION.........>.........>.........>.........>.........>.....

Source	Sum of Squares	df	F - Ratio	Significance
1000000000 Adhesive	7.06	1	33.724	0.997
0100000000 Adhesive	0.452	1	2.16	0.8
0010000000 Resin to	3.222	1	15.392	0.988
0001000000 Mix Humid	1.856	1	8.868	0.969
0000100000 Open Time	0.912	1	4.357	0.91
0000010000 Cure Temp	0.127	1	0.607	Undefin
0000001000 Degreasin	2.696	1	12.88	0.984
0000000100 Vacuum Cl	0.007	1	0.032	Undefin
0000000010 Cure Time	18.503	1	88.39	1
0000000001 Steel Sur	32.036	1	153.036	1

REGRESSION SUMMARY

Source	Sum of Squares	df	Mean Square
Regression Model			
Factors	66.871	10	6.687
Residuals - Total	1.047	5	0.209
Lack of Fit	1.047	5	0.209
Pure Error	0	0	0
Totals	67.917	15	

Statistics	F - Ratio	Probability
MS-Factors/MS-Residuals	31.945	0.999
MS-Factors/MS-Pure Error	Undefined	Undefined
MS-Lack of Fit/MS-Pure Error	Undefined	Undefined

Fitted Response	Standard Error	df
Bond Strength	0.458	5

Coefficient of Determination	
R-squared	0.985
R-squared, adjusted	0.954
Coefficient of Variation	0.006

Subgroups	
Number	16
Average Size	1
Minimum Size	1
Maximum Size	1

FITTED PARAMETERS.........>.........>........>.........>.........>.........>........>.........>.........>.....

Source / Parameter	Levels	Coefficient	Standard Error	Transmitted Variance	Sum of Squares (Partial SS)	t-Ratio	Level of Significance
0000000000 Mean	0	8.662	0.379	0	0	0	0
1000000000 Adhesiv	2	-1.329	0.229	0.1	7.06	-5.807	0.998
0100000000 Adhesiv	2	0.336	0.229	0.1	0.452	1.47	0.798
0010000000 Resin t	2	-0.897	0.229	0.1	3.222	-3.923	0.989
0001000000 Mix Hum	2	-0.681	0.229	0.1	1.856	-2.978	0.969
0000100000 Open Ti	2	-0.477	0.229	0.1	0.912	-2.087	0.909
0000010000 Cure Te	2	0.178	0.229	0.1	0.127	0.779	0.529
0000001000 Degreas	2	-0.821	0.229	0.1	2.696	-3.589	0.984
0000000100 Vacuum	2	0.041	0.229	0.1	0.007	0.178	0.134
0000000010 Cure Ti	2	-2.151	0.229	0.1	18.503	-9.402	1
0000000001 Steel S	2	-2.83	0.229	0.1	32.036	-12.371	1

No correlation exists among the parameters.

Statistical Methods and Analytical Models

DOE KISS

Row #	A	B	C	D	E	F	G	H	I	J
1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
2	-1	-1	-1	1	-1	-1	1	-1	1	1
3	-1	-1	1	-1	-1	1	-1	1	-1	1
4	-1	-1	1	1	-1	1	1	1	1	-1
5	-1	1	-1	-1	1	-1	-1	1	1	-1
6	-1	1	-1	1	1	-1	1	1	-1	1
7	-1	1	1	-1	1	1	-1	-1	1	1
8	-1	1	1	1	1	1	1	-1	-1	-1
9	1	-1	-1	-1	1	1	1	-1	-1	-1
10	1	-1	-1	1	1	1	-1	-1	1	1
11	1	-1	1	-1	1	-1	1	1	-1	1
12	1	-1	1	1	1	-1	-1	1	1	-1
13	1	1	-1	-1	-1	1	1	1	1	-1
14	1	1	-1	1	-1	1	-1	1	-1	1
15	1	1	1	-1	-1	-1	1	-1	1	1
16	1	1	1	1	-1	-1	-1	-1	-1	-1

FACTOR	COEF	P(2 TAIL)	TOL	LOW	HIGH	EXPER	ACTIVE
Constant	4.2510	Not Avail					
A	0.0000	Not Avail		-1	1	-1	X
B	0.0000	Not Avail		-1	1	-1	X
C	0.0000	Not Avail		-1	1	-1	X
D	0.0000	Not Avail		-1	1	-1	X
E	0.0000	Not Avail		-1	1	-1	X
F	-1.2250	Not Avail		-1	1	-1	X
G	0.0000	Not Avail		-1	1	-1	X
H	0.0000	Not Avail		-1	1	-1	X
I	0.0000	Not Avail		-1	1	-1	X
J	0.0000	Not Avail		-1	1	-1	X
K	0.0000	Not Avail					X
L	0.0000	Not Avail					X
M	0.0000	Not Avail					X
N	0.0000	Not Avail					X
O	0.0000	Not Avail					X
R Sq	1.0000						
Adj R Sq	Not Avail						
Std Error	0.0000						
F	0.0000		**PRED Y**			5.476	
Sig F	Not Avail						

FACTOR	COEF	P(2 TAIL)	TOL	LOW	HIGH	EXPER	ACTIVE
Constant	4.3460	Not Avail					
A	-0.1982	Not Avail	1.000	-1	1	-1	X
B	0.1681	Not Avail	1.000	-1	1	-1	X
C	-0.4488	Not Avail	1.000	-1	1	-1	X
D	0.0334	Not Avail	1.000	-1	1	-1	X
E	0.0204	Not Avail	1.000	-1	1	-1	X
F	-1.4150	Not Avail	1.000	-1	1	-1	X
G	0.0069	Not Avail	1.000	-1	1	-1	X
H	0.2029	Not Avail	1.000	-1	1	-1	X
I	-0.0460	Not Avail	1.000	-1	1	-1	X
J	-0.0359	Not Avail	1.000	-1	1	-1	X
K	0.0891	Not Avail	1.000				X
L	-0.1025	Not Avail	1.000				X
M	-0.3144	Not Avail	1.000				X
N	-0.1443	Not Avail	1.000				X
O	-0.2388	Not Avail	1.000				X
R Sq	1.0000						
Adj R Sq	Not Avail						
Std Error	0.0000						
F	0.0000		**PRED Y**			**6.05825**	
Sig F	Not Avail						

FACTOR	COEF	P(2 TAIL)	TOL	LOW	HIGH	EXPER	ACTIVE
Constant	4.2510	Not Avail					
A	-0.4660	Not Avail	1.000	-1	1	-1	X
B	0.0000	Not Avail	1.000	-1	1	-1	X
C	0.0000	Not Avail	1.000	-1	1	-1	X
D	-0.3740	Not Avail	1.000	-1	1	-1	X
E	0.0000	Not Avail	1.000	-1	1	-1	X
F	-1.2250	Not Avail	1.000	-1	1	-1	X
G	-0.3080	Not Avail	1.000	-1	1	-1	X
H	0.0000	Not Avail	1.000	-1	1	-1	X
I	-0.7610	Not Avail	1.000	-1	1	-1	X
J	0.0000	Not Avail	1.000	-1	1	-1	X
K	0.0000	Not Avail	1.000				X
L	0.0000	Not Avail	1.000				X
M	0.0000	Not Avail	1.000				X
N	0.0000	Not Avail	1.000				X
O	0.0000	Not Avail	1.000				X
R Sq	1.0000						
Adj R Sq	Not Avail						
Std Error	0.0000						
F	0.0000		PRED Y			7.385	
Sig F	Not Avail						

FACTOR	COEF	P(2 TAIL)	TOL	LOW	HIGH	EXPER	ACTIVE
Constant	4.3460	Not Avail					
A	-0.6643	Not Avail		-1	1	-1	X
B	0.1681	Not Avail		-1	1	-1	X
C	-0.4488	Not Avail		-1	1	-1	X
D	-0.3406	Not Avail		-1	1	-1	X
E	0.0204	Not Avail		-1	1	-1	X
F	-1.4150	Not Avail		-1	1	-1	X
G	-0.3011	Not Avail		-1	1	-1	X
H	0.2029	Not Avail		-1	1	-1	X
I	-0.8070	Not Avail		-1	1	-1	X
J	-0.0359	Not Avail		-1	1	-1	X
K	0.0891	Not Avail					X
L	-0.1025	Not Avail					X
M	-0.3144	Not Avail					X
N	-0.1443	Not Avail					X
O	-0.2388	Not Avail					X
R Sq	1.0000						
Adj R Sq	Not Avail						
Std Error	0.0000						
F	0.0000		**PRED Y**			7.96725	
Sig F	Not Avail						

Y1	Y2	Y3	Y4	YBAR	S
5.48	6.769	7.385	8.678	7.077	1.331181
5.48	5.086	4.499	4.109	4.7925	0.607352
3.03	2.159	4.935	4.068	3.547	1.210505
3.03	3.409	2.049	2.432	2.729	0.605865
5.48	6.667	5.863	7.054	6.265	0.723015
5.48	7.11	6.021	7.655	6.5655	0.994482
3.03	2.421	3.413	2.808	2.917	0.414646
3.03	2.733	3.571	3.278	3.152	0.357246
3.03	2.464	3.387	2.825	2.9255	0.385644
3.03	3.376	1.733	2.083	2.5545	0.77338
5.48	5.37	5.837	5.731	5.6035	0.217223
5.48	4.79	4.183	3.497	4.4865	0.845073
3.03	3.289	1.865	2.128	2.577	0.687287
3.03	3.597	3.255	3.826	3.426	0.355191
5.48	5.362	4.315	4.201	4.8385	0.673527
5.48	4.934	5.705	5.163	5.3195	0.339708

FACTOR	COEF	P(2 TAIL)	TOL	LOW	HIGH	EXPER	ACTIVE
Constant	4.2985	***0.0000***					
A	-0.3321	***0.0006***	1	-1	1	-1	X
B	0.0841	0.3597	1	-1	1	-1	X
C	-0.2244	***0.0172***	1	-1	1	-1	X
D	-0.1703	***0.0671***	1	-1	1	-1	X
E	0.0102	0.9112	1	-1	1	-1	X
F	-1.3200	***0.0000***	1	-1	1	-1	X
G	-0.1506	0.1042	1	-1	1	-1	X
H	0.1014	0.2700	1	-1	1	-1	X
I	-0.4035	***0.0001***	1	-1	1	-1	X
J	-0.0179	0.8444	1	-1	1	-1	X
K	0.0446	0.6262	1				X
L	-0.0513	0.5755	1				X
M	-0.1572	***0.0902***	1				X
N	-0.0721	0.4314	1				X
O	-0.1194	0.1953	1				X
R Sq	0.8463						
Adj R Sq	0.7983						
Std Error	0.7272						
F	17.6235		**PRED Y**			**6.72163**	
Sig F	0.0000						

FACTOR	COEF	P(2 TAIL)	TOL	LOW	HIGH	EXPER	ACTIVE
Constant	0.6576	Not Avail					
A	-0.1230	Not Avail	1	-1	1	-1	X
B	-0.0894	Not Avail	1	-1	1	-1	X
C	-0.0746	Not Avail	1	-1	1	-1	X
D	-0.0478	Not Avail	1	-1	1	-1	X
E	-0.0687	Not Avail	1	-1	1	-1	X
F	-0.0589	Not Avail	1	-1	1	-1	X
G	-0.0915	Not Avail	1	-1	1	-1	X
H	0.0472	Not Avail	1	-1	1	-1	X
I	0.0087	Not Avail	1	-1	1	-1	X
J	-0.0018	Not Avail	1	-1	1	-1	X
K	0.0557	Not Avail	1				X
L	-0.2015	Not Avail	1				X
M	0.0280	Not Avail	1				X
N	-0.0431	Not Avail	1				X
O	-0.0129	Not Avail	1				X
R Sq	1.0000						
Adj R Sq	Not Avail						
Std Error	0.0000						
F	0.0000		**PRED S**			**1.15736**	
Sig F	Not Avail						

Statistical Methods and Analytical Models

Q-EDGE

	A	B	H	C	J	E	F	D	I	G
1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	2	2	2
3	1	1	1	2	2	2	2	1	1	1
4	1	1	1	2	2	2	2	2	2	2
5	1	2	2	1	1	2	2	1	1	2
6	1	2	2	1	1	2	2	2	2	1
7	1	2	2	2	2	1	1	1	1	2
8	1	2	2	2	2	1	1	2	2	1
9	2	1	2	1	2	1	2	1	2	1
10	2	1	2	1	2	1	2	2	1	2
11	2	1	2	2	1	2	1	1	2	1
12	2	1	2	2	1	2	1	2	1	2
13	2	2	1	1	2	2	1	1	2	2
14	2	2	1	1	2	2	1	2	1	1
15	2	2	1	2	1	1	2	1	2	2
16	2	2	1	2	1	1	2	2	1	1

Model Results Q1.

Effct	Coeff	p2t	Hi	Low	Expr
Const	4.251				
A	-0.00	*****	2.0000	1.0000	1.5000*
B	-0.00	*****	2.0000	1.0000	1.5000*
E	0.000	*****	2.0000	1.0000	1.5000*
C	0.000	*****	2.0000	1.0000	1.5000*
F	-1.22	*****	2.0000	1.0000	1.5000*
G	0.000	*****	2.0000	1.0000	1.5000*
H	0.000	*****	2.0000	1.0000	1.5000*
D	0.000	*****	2.0000	1.0000	1.5000*
I	0.000	*****	2.0000	1.0000	1.5000*
J	0.000	*****	2.0000	1.0000	1.5000*
ABD	0.000	*****			*
-CD	0.000	*****			*
ACD	0.000	*****			*
BCD	0.000	*****			*
-ABCD	0.000	*****			*

Ypred = 4.25

Model Results Q2.

Effct	Coeff	p2t	Hi	Low	Expr
Const	4.346				
A	-0.19	*****	2.0000	1.0000	1.5000*
B	0.168	*****	2.0000	1.0000	1.5000*
E	0.020	*****	2.0000	1.0000	1.5000*
C	-0.44	*****	2.0000	1.0000	1.5000*
F	-1.41	*****	2.0000	1.0000	1.5000*
G	0.203	*****	2.0000	1.0000	1.5000*
H	0.089	*****	2.0000	1.0000	1.5000*
D	0.033	*****	2.0000	1.0000	1.5000*
I	0.007	*****	2.0000	1.0000	1.5000*
J	-0.04	*****	2.0000	1.0000	1.5000*
ABD	-0.10	*****			*
-CD	-0.03	*****			*
ACD	-0.31	*****			*
BCD	-0.14	*****			*
-ABCD	-0.23	*****			*

Ypred = 4.35

Model Results 83.

Effct	Coeff	p2t	Hi	Low	Expr
Const	4.251				
A	-0.46	*****	2.0000	1.0000	1.5000*
B	0.000	*****	2.0000	1.0000	1.5000*
J	-0.00	*****	2.0000	1.0000	1.5000*
C	0.000	*****	2.0000	1.0000	1.5000*
E	-1.22	*****	2.0000	1.0000	1.5000*
F	-0.00	*****	2.0000	1.0000	1.5000*
G	-0.00	*****	2.0000	1.0000	1.5000*
D	-0.37	*****	2.0000	1.0000	1.5000*
H	0.000	*****	2.0000	1.0000	1.5000*
I	-0.00	*****	2.0000	1.0000	1.5000*
ABD	-0.30	*****			*
-CD	-0.00	*****			*
ACD	-0.76	*****			*
BCD	0.000	*****			*
-ABCD	-0.00	*****			*

Ypred = 4.25

Model Results Q4.

Effct	Coeff	p2t	Hi	Low	Expr
Const	4.346				
A	-0.66	*****	2.0000	1.0000	1.5000*
B	0.168	*****	2.0000	1.0000	1.5000*
E	0.020	*****	2.0000	1.0000	1.5000*
C	-0.44	*****	2.0000	1.0000	1.5000*
F	-1.41	*****	2.0000	1.0000	1.5000*
G	0.203	*****	2.0000	1.0000	1.5000*
H	0.089	*****	2.0000	1.0000	1.5000*
D	-0.34	*****	2.0000	1.0000	1.5000*
I	-0.75	*****	2.0000	1.0000	1.5000*
J	-0.35	*****	2.0000	1.0000	1.5000*
ABD	-0.10	*****			*
-CD	-0.03	*****			*
ACD	-0.31	*****			*
BCD	-0.14	*****			*
-ABCD	-0.23	*****			*

Ypred = 4.35

Model Results Q1234.

Effct	Coeff	p2t	Hi	Low	Expr
Const	4.298				
F	-1.32	0.000	2.0000	1.0000	1.5000*
I	-0.37	0.000	2.0000	1.0000	1.5000*
A	-0.33	0.001	2.0000	1.0000	1.5000*
C	-0.22	0.020	2.0000	1.0000	1.5000*
J	-0.17	0.061	2.0000	1.0000	1.5000*
D	-0.17	0.071	2.0000	1.0000	1.5000*
ACD	-0.15	0.094			*
-ABCD	-0.11	0.199			*
G	0.101	0.274	2.0000	1.0000	1.5000*
B	0.084	0.363	2.0000	1.0000	1.5000*
BCD	-0.07	0.434			*
ABD	-0.05	0.577			*
H	0.045	0.628	2.0000	1.0000	1.5000*
-CD	-0.01	0.845			*
E	0.010	0.912	2.0000	1.0000	1.5000*

Ypred = 4.30

	A	B	H	C	J	E	F	D	I	G
1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	2	2	2
3	1	1	1	2	2	2	2	1	1	1
4	1	1	1	2	2	2	2	2	2	2
5	1	2	2	1	1	2	2	1	1	2
6	1	2	2	1	1	2	2	2	2	1
7	1	2	2	2	2	1	1	1	1	2
8	1	2	2	2	2	1	1	2	2	1
9	2	1	2	1	2	1	2	1	2	1
10	2	1	2	1	2	1	2	2	1	2
11	2	1	2	2	1	2	1	1	2	1
12	2	1	2	2	1	2	1	2	1	2
13	2	2	1	1	2	2	1	1	2	2
14	2	2	1	1	2	2	1	2	1	1
15	2	2	1	2	1	1	2	1	2	2
16	2	2	1	2	1	1	2	2	1	1
17										
18										
19	0	0	0	0	0	0	0	0	0	0
20										
21	4.631	4.214	4.288	4.523	5.618	4.197	4.254	4.469	4.676	4.475
22	3.966	4.383	4.309	4.074	2.978	4.400	4.343	4.128	3.921	4.121
23										
24	−0.26	−0.56	−0.43	−0.45	−0.45	−0.65	−0.63	−0.30	−0.48	−0.61
25	−0.85	−0.55	−0.68	−0.65	−0.65	−0.46	−0.47	−0.81	−0.63	−0.49
26										
27	12.29	11.63	11.77	12.12	14.73	11.69	11.83	11.92	12.62	12.15
28	11.38	12.04	11.90	11.55	8.938	11.98	11.84	11.75	11.05	11.52

	*	*	*	*	*	Y1	Y2	Y3	Y4	Ybar
1						5.476	6.769	7.385	8.678	7.077
2						5.476	5.086	4.499	4.109	4.792
3						3.026	2.159	4.935	4.068	3.547
4						3.026	3.409	2.049	2.432	2.729
5						5.476	6.667	6.769	7.96	6.718
6						5.476	7.11	5.115	6.749	6.112
7						3.026	2.421	4.319	3.714	3.37
8						3.026	2.733	2.665	2.372	2.699
9						3.026	2.464	2.481	1.919	2.472
10						3.026	3.376	2.639	2.989	3.007
11						5.476	5.37	4.931	4.825	5.150
12						5.476	4.79	5.089	4.403	4.939
13						3.026	3.289	1.865	2.128	2.577
14						3.026	3.597	3.255	3.826	3.426
15						5.476	5.362	4.315	4.201	4.838
16						5.476	4.934	5.705	5.163	5.319
17										4.298
18										
19	*****	*****	*****	*****	*****					
20										
21	4.350	4.316	4.456	4.371	4.418					
22	4.247	4.281	4.141	4.226	4.179					
23										
24	-0.45	-0.57	-0.66	-0.43	-0.53					
25	-0.65	-0.54	-0.45	-0.68	-0.58					
26										
27	11.83	11.62	12.18	11.96	11.99					
28	11.84	12.04	11.49	11.71	11.68					

	Yprd	SD	S/N
1	5.996	1.331	16.64
2	5.241	0.607	13.45
3	3.356	1.211	9.73
4	2.601	0.606	8.221
5	5.996	1.015	16.31
6	5.241	0.966	15.48
7	3.356	0.824	9.94
8	2.601	0.268	8.526
9	2.601	0.452	7.521
10	3.356	0.301	9.465
11	5.241	0.321	14.20
12	5.996	0.455	13.79
13	2.601	0.687	7.508
14	3.356	0.355	10.59
15	5.241	0.674	13.50
16	5.996	0.340	14.48
17			
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