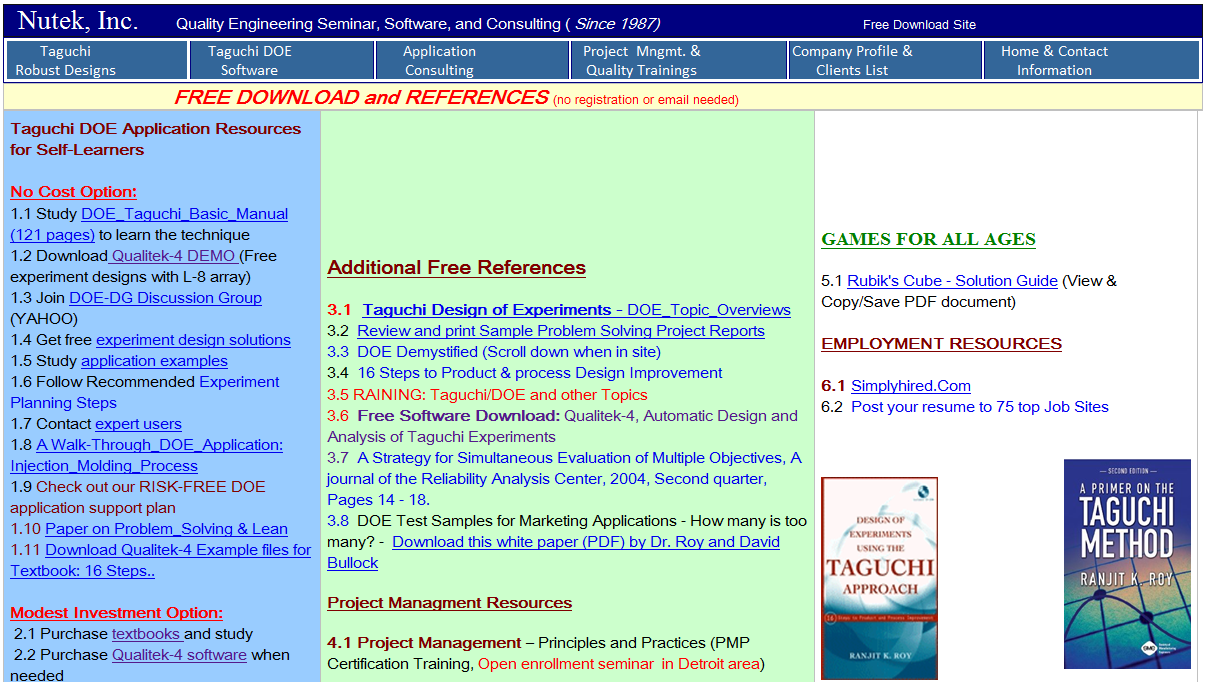
Taguchi DOE Application Discussions

Question and Answers (Q&A) – Part I

This document contains part of discussions that took place during 1996 – 2005 from worldwide practitioners of the Taguchi experimental design technique. There are over 110 Q&A's contained in the two documents (Part I & II). These two documents as well as other materials included in the web site below are available free to all. The Q&A are arranged in reverse chronological manner. To join current discussion group, join forum supported by Google at (http://groups.google.com/group/TDA-DG?hl=en&lnk=gcimh)

- Ranjit Roy, Author and Consultant, Jan. 20, 2011 www.nutek-us.com

Site Link: http://nutek-us.com/wp-free.html



Our Other Reference Sites:

-Robust Product and Process Designs (Taguchi/DOE) *seminar* (http://nutek-us.com/wp-s4d.html)

-Taguchi/DOE, Six Sigma, and Project Management (http://nutek-us.com/wp-sem.html)

-Qualitek-4 Software (Free working DEMO (http://nutek-us.com/wp-q4w.html)

-Free downloadable DOE/Taguchi resources (http://nutek-us.com/wp-free.html)

-References & Textbooks (http://nutek-us.com/wp-txt.html)

-Taguchi DOE Application Discussion Group (TDA-DG), (http://groups.google.com/group/TDA-DG?hl=en&lnk=gcimh)

Topic /Ref : DOE for SOFTWARE evaluations (Ref: DOE-DG02-981125)	
Question	**Answer/Discussion**
I have downloaded your software for the purpose of applying it to design test cases for software testing... Do you feel that Taguchi methods or fractional factorial methods can be actually used for software testing ? I shall be grateful if you can send me some information about this Aspect of applying DOE techniques... Thanking you... - Ajit Kulkarni	*Your question relates to use of DOE for SOFTWARE evaluations.* *Can it be used for software?* *The answer is yes depending on how you define your objective.* *In late eighty's, when I first started full time consulting and training, I was contracted by Dr. H. Ghosh, the then VP of Quality for UNISYS, to teach DOE/Taguchi methods to their plants all over the country. Seminar attendees from Unisys had numerous projects dealing with software evaluation. Although my public and onsite seminars now mostly attracts manufacturing, design, and quality professionals, once in a while I do come across people interested in software applications.* *Use of DOE for software is similar to use in any analytical simulations (like Finite Element Analysis for simulation of structural deflection, stress and vibration). The difficulty is to define the objective properly. Remember that DOE is for STUDY OF MULTIPLE VARIABLES SIMULTANEOUSLY. Wherever and whenever the performance (from hardware samples or analytical simulation model) is dependent on many variables (or call it FACTORS), DOE can help you objectively study their influence and determine the most desirable combination of the factors. Thus, if we determine that in the process of assuring quality of the software under consideration, we suspect that there are several things that are known to be altered/modified by the users, then perhaps, the performance can be optimized by testing it before the customers do.* *There are two aspects of testing software for assuring quality before release.* *(1) Assure that the code is free from BUGS ad that all calculations and descriptions and accurate. This is careful work for the development group. I don't know a good and general way to use DOE for this.* *(2) The second thing that might be of interest to you is to evaluate your software in terms of its ability to be applied thousands of ways by the users and produce satisfactory results or reduce possibility of any interruption/crash. How can possibly try thousands of possibly ways the user can define their input parameters to run the program?* *Consider a software package that allows users to input 15 different factors that control the result. If each of the input factor is to have two values (most simple case), then there will be over 32,000 possible combinations of the input parameters. In other words, the software may be run with over 32,000 distinct input combinations? Do we want all of them to work well?* *Do we suspect that under certain combination of the input parameters, the program might be susceptible to hitting more roadblocks than other situation? If so, then we must check it out. But how do you check the program without actually trying all possibilities? This is where DOE will be useful. In this example case you can layout your program runs (design experiments) using an L-16 Orthogonal array, run program 16 times, and be able to increase your probability of detecting any possible execution difficulties/crashes. Your goal, of course, will be to find out the input condition most likely to encounter crashes, run them repeatedly and fix the codes.* *- RKR, 98-1124*

Question	Answer / Discussion
…….. ... suppose I conduct a real life experiment with some interactions among the inputs along with some uncontrolled factors, it is possible that if I repeat the experiment after a lapse of some finite time, Without changing the input values, then I might get output values different from those Obtained in the earlier experiment. However, this cannot happen in the software. Even if I supply the same inputs after some finite time under the same conditions like platform, I will get the same outputs. In other words, in s/w the experimental environment doesn't change or there are hardly any uncontrolled factors.... - Ajit Kulkarni	*Once the factors are indentified, the interaction among the factors can be easily studied just as you would for experiments with hardware. I think this point is quite clear to you. Your question deals with UNCONTROLLABLE/NOISE FACTORS. These are there in real life and they are the primary causes of variation. How can you include them, and study them in your simulations?* *You are correct. Unless you are able to identify and include them in your simulation, repeating your simulation runs will not produce any difference in results and thus there is no need to repeat your runs.* *So, how can you pursue ROBUST NESS studies using simulations?* *If your goal is to study and reduce variations, you must identify the Noise factors which are uncontrollable in real applications, but control them in the laboratory environment for the sake of conducting the experiments. In case of simulations, you must include the effects of the Noise factors in your analytical equations just as you do for any other factors. Later, while running the simulations, you need to randomly or as per the OUTER ARRAY design, vary the Noise factors. After you collect multiple results in the same trial condition, you should pursue SIGNAL TO NOISE RATION analysis to determine the optimum condition.* *In summary then, here are the topics you will need to muster and apply :* *For simple design optimization, you need* - *Experiment designs with standard orthogonal arrays* - *Interaction studies* - *Mixed-level factor designs* - *Anlysis of results using average results* *When you have multiple sample results/Outer arry design, you should learn* - *Signal-to-Noise Ratio analysis* - *Outer array design* - *Principles of ROBUSTNESS* - RKR, 98-1125 -

Topic /Ref : ANOVA & Pooling (Ref : DOE-DG05-980818)

Question	Answer / Discussion
I'm begining to use the Taguchi experiments, and I'm getting any doubts. If you could help me, I'll be thankful. I was planning a experiment with 3-2LF, using a L-4, then I realized that the error DOF became zero. It's happened becase I had just 1(one) response of each trial condition so, the total DOF was the same as the sum of factors DOF's. And now, I don't know how to calculate the F-ratio. -Jederson Cezaro Enginner, Irmaos Zen S.A.	*Your question deals with ANOVA terms such as F-ratio, Error factor, etc. when you fill all columns of the Orthogonal array with factors or interactions. In your case you have an L-4 used to study three 2-level factors.* *In this and other cases where there is no empty to column to start with, you will have zero error degree of freedom to start with. Generally, you will have some columns (factor or interaction assigned) with smaller influence (smaller percentage in the last column of ANOVA) which need to be, arbitrarily POOLED. Once you have POOLED one or more factors/interactions, with the error degrees of freedom now greater than zero, you are able to test for the SIGNIFICANCE and POOL as you see fit.* *So what should you do in your case of three 2-level factors. Hope that you get one factor with much less influence than the other two. If you do, then you should POOL this factor arbitrarily, and proceed for revising ANOVA. On the other hand, if all factor influences are comparable (there is no numeric level that can be assigned, like below 5%, or 2%, etc), you must forget about calculating F-ratios and any other calculations derived from it.* *Good luck and thank you for your interest in pursuing the experiments.* **- RKR, 98-0818**

Topic /Ref : Overall Evaluation Criteria (OEC	(Ref : DOE-DG06-990202)
Question	Answer / Discussion

I encounter problem when using OEC function. Suppose I want to optimise
a nominal-the-best QC with the best value of 2. What should I do if the worst value is between 1 and 3. I could not treat the worst value to be 1 only because my output response could be 2.5 which is out of the range
between 1-2. Please clear my doubts soon.Thanks.

-Chong Chuanming

I'm pleased that you are attempting to use Overall Evaluation Criteria (OEC) concepts in your DOE applications using Qualitek-4 software. I will try and give you some background which may help you understand it better, but you may need to do some follow up studies.

The OEC concept to handle multiple criteria of Evaluation was first published in THE PRIMER ON THE TAGUCHI METHOD – R. Roy in late 1980's. Since then we have incorporated it in my training and in Qualitek-4 software. Lately, we also have a site where you can get some information about OEC (http://nutek-us.com/wp-oec.html). You will benefit from some of these references.

I understand (or will assume) your question relates to formulating OEC (which will be sample RESULTS for DOE analysis) which are calculated using the OEC option from the RESULT menu of Qualitek-4 software. I'm also assuming the SMALLER and BIGGER quality characteristics are clear to you. Obviously the WORST and the BEST performances are found from the readings obtained after experiments (samples) are completed. While these are straightforward in these two quality characteristics, it is somewhat obscured in case of NOMINAL IS THE BEST (Nominal). In this case, obviously the best value is the TARGET (or nominal) value. The WORST value then becomes the reading that is worst deviant from the target. For example, if your readings range between 1 and 9, and the target is 6. Then the worst deviant will be 6-1 = 5 instead of 9 – 6 = 3.

In addition to determining what the BEST and WORST readings are, you also need to recognize that in the formulation of OEC, a NOMINAL situation is transformed to SMALLER quality characteristic by using the deviation of the reading from the target (absolute value). Thus a reading of 7 will be considered as a deviation of 7- 6 = 1 which is normalized by dividing by the worst deviant reading.

- RKR, 99-0202

Topic /Ref : Experiment design with 3-Level Factors (Ref : DOE-DG06-990203)	
Question	Answer / Discussion

I came across your website while browsing the net for a good DOE software. Though I had problems downloading your demo program, I will try it once again.

In the meantime I will appreciate if you could please send me a DOE trial matrix for one of my students who would like to conduct an experiment with 5 variables, each having 3 levels. We want to have the number of trials much less than 5^3=125. I hope you will please help us in this academic exercise.

Thanking you,

Yours Sincerely,

With Warm Regards,

Dr. Amiya R. Mohanty, Asst. Professor, Department of Mechanical Engineering, Indian Institute of Technology, Kharagpur, INDIA

Thank you for your interest in the Taguchi approach to experimental designs. I'm glad that you found our sites informative. Hopefully you will have success in downloading our Qualitek-4 DEMO software when you try next time.

The five 2-level factors your student wants to study can be conveniently studied by using the L-18 Orthogonal array. L-18 array (2^1 col. 1 and 3^7 in cols. 2 - 8) can accommodate ONE 2-level factor and up to SEVEN 3-level factors. In designing the experiment, the FIVE 3-level factors can be assigned to columns 2 – 7, leaving column 8 and column 1 empty. Although, since the capacity to study TWO additional factors come without extra experiments, it would be good to include more factors along with the five that are considered for the study.

Any text book on the Taguchi method will have L-18. Upon assignment of the factor, the description of the 18 experiments can be obtained by reading the rows of the array and expressing it in terms of the factor level descriptions.

As you are perhaps aware that Qualitek-4 DEMO only would allow you to design your own experiments as long as you use L-8 array. Should your student wishes to use the DEMO software for his/her FIVE factor experiments, all factors must be at TWO LEVELS. An L-8 array can accommodate up to SEVEN 2-level factors.

I hope this helps. For further tips with experiment designs, please feel free to visit our site http:/nutek-us.com/wp-tip.html .

- RKR, 99-0203

*…… As Dr. Roy suggested, you may please use an L-18 Orthogonal array which allows one to study eight factors, seven of them at 3-levels and one at 2-levels. Remember, the number of degrees of freedom for a factor is one less than the number of levels associated with it. Therefore a 3-level factor has two degrees of freedom and a 2-level factor has one degree of freedom. Therefore you may get [(2 * 7) +1] = 15 degrees of freedom. The number of degrees of freedom associated with an L-18 OA is equal to 17 (obtained by one less than the number of trials). This is tyhe main reason Dr. Roy has recommended an L-18 OA for your objective. So far so good!!!. However in your case, you have to study only five factors at 3-levels. So you will have 10 degrees of freedom. Now how to assign your factors to the OA is the next stage. You need to be very careful while handling OA's as the main factor effects are confounded with two-factor interactions. For an L-18 OA,*

an interaction is built in between the first two columns. This interaction information can be obtained without sacrificing any other column. Interactions between 3-level columns are distributed more or less uniformly to all the other 3-level columns, which allows you to investigate main effects. I would therefore suggest you to assign your factors of interest to columns 3,4,5, 6 and 7. Leave the first two columns and the last column empty. Taguchi divides an L-18 column into three groups - group represents the first column at 2-levels, group 2 represents the first 3-level column and then group three all the remaining 3-level columns. As I accentuated above, it is wiser not to assign factors (in your case) in the first two columns as an interaction is built-in between them.

Should you have any queries, I am quite pleased to guide you. Hope the experiment would be useful for your student's project.

Regards

Dr Jiju Antony (B.E., M.Eng.Sc, PhD)
Research Fellow,Department of AMS, Portsmouth Business School
University of Portsmouth

Topic /Ref : Multiple Objectives (Ref : DOE-DG08-990207)	
Question	Answer / Discussion

Hello Dr. Roy,

I have a similar situation here at Comptec trying to design an experiment on injection molding process where two objectives are sought for and must be combined into a single OEC. The first objective is for an increase in cosmetic quality, thus BIGGER IS BETTER quality characteristic, and the other objective is to meet a dimensional specification, 240+/-0.50 mm, which calls for NOMINAL (TARGET) IS BEST. …….

I touched on this issue during your seminar in Detroit.

My design is an L8 with six process variables. Each trial condition shall be repeated 25 times and the average value used for the analysis. To simplify it, we intend to disregard interactions.

- Kwame Dickson

Your effort in combining two criteria of evaluations, one BIGGER and the other NOMINAL quality characteristics, is in the right direction. The NOMINAL criteria readings must always be reduced to difference in reading from the Target/Nominal value (if reading is 240.3, then it will be 240.3 – 240 = 0.3). This must then be normalized by dividing by the worst deviation (0.50). Thus your normalized reading will be (0.30/0.50) which will carry a SMALLER QC. Now to combine this with the BIIGER criteria reading, you will subtract the normalized value from 1.

[1 - (0.30/0.50)] x Relative Weighting.

If you are using Qualitek-4 in preparing your OEC (OEC option from the RESULT menu), the program will automatically incorporate the above approach when you describe the criteria of evaluations apprpriately.

==========

Read about Qualitek-4 in QUALITY DIGEST, January 1999 issue, page 51.

==========

- RKR, 99-0207

Topic /Ref : Qualitek-4 Software Capabilities (Ref : DOE-DG09-990211)	
Question	Answer / Discussion

I am looking at Qualitek-4 for Taguchi design demo and I have a number of questions relating to that as well:

1. Is there a maximum number of factors/levels/responses that can be entered?

2. Is there complete links (export & import) with Excel & Access?

3. The arrays, (as I only have the demo version I can't look into this), does Qualitek automatically choose the array required relating to levels & factors? Can the arrays be ammended for our particular needs?

4. How do you enter the number of responses & the details of those responses?

If you could answer any of these question or pass this on to someone who could answer, I would be very gratefull!
-Sally Robinson
Xerox Ltd Technical Centre
Herts, AL7 1HE, England

1. Is there a maximum number of factors/levels/responses that can be entered?

63 FACTORS AT 2-LEVEL
LEVELS AT 2, 3, OR 4
RESPONSES CAN BE MULTIPLE AND YOU HAVE OPTION TO COMBINE THEM USING A SPECIAL SCHEME (please read about it at http://www.rkroy.com/wp-oec.html, http://www.rkroy.com/wp-tec.html)

2. Is there complete links (export & import) with Excel & Access?

THE EXPORT IMPORT OPTION EXIST VIA TEXT FILE FROM ANY PROGRA?.

3. The arrays, (as I only have the demo version I can't look into this), does Qualitek-4 automatically choose the array required relating to levels & factors? Can the arrays be amended for our particular needs?

EVEN IN DEMO YOU CAN REVIEW OVER 50 EXAMPLE EXPERIMENTS INCLUDED IN THE PROGRAM. ARRAYS CAN BE MODIFIED TO ALLOW YOU TO UPGRADE AND DOWNGRADE COLUMNS.

4. How do you enter the number of responses & the details of those responses?

MULTIPLE CRITERIA OF EVALUATION (EACH RESPONSES EVALUATED BY A SEPARATE CRITERIA OF EVALUATION). THE DETAILS OF THE RESPONSES CAN BE ENTERED USING Overall Evaluation Criteria (OEC) option from RESULT menu. BEFORE USING OEC YOU MUST MAKE YOURSELF FAMILIAR WITH THE PROCESS OF COMBINING MULTIPLE CRITERIA. SINCE IT IS NOT A INDUSTRY STANDARD PRACTICE/METHOD, YOU MUST REFER TO THE WRITEUP OFFERED AT (http://www.rkroy.com/wp-oec.html). I SPEND A GOOD AMOUNT OF TIME DISCUSSING HOW TO HANDLE MULTIPLE CRITERIA IN MY 4-DAY ONSITE SEMINAR/WORKSHOP.

- RKR, 99-0211

Topic /Ref : Experiment design with 4-Level Factors (Ref : DOE-DG10-990224)	
Question	Answer / Discussion
Could you please tell me how I can get the orthogonal array table which I will need to design an experiment with 4 factors at 4 levels each. I would appreciate if you could help me with this. - Amarendra Kumar	*You can study FOUR 4-level factors conveniently by 16 experiments. You will need a modified L-16 (4^5) Orthogonal array to design your experiment. This array has FIVE 4-level columns. The experiment can be designed simply by assigning the four factors to the first four columns of the array.* *Orthogonal Arrays can be found in any available text book on Taguchi approach. You can also print out the files containing this array in our Qualitek-4 software. Once you have installed the Qualitek-4 software which (I'm assuming) you downloaded from our site (http://www.rkroy.com) you can review/print file DATA-M16. This file is in the sub-directory DATA under the directory, which you named for Qualitek-4.* *You can view this and other DATA files containing the arrays and tables by being in the DOS prompt and executing commands like > EDIT DATA-M16 .* - RKR, 99-0224

Topic /Ref : Missing Experimental Results/Data (Ref : DOE-DG11-990413)

Question	Answer / Discussion
L32 array, modified to accommodate 2 4-levels factors and 1 3-levels factor (dummy treated), for a total of 17 DOF for factors, before pull-up fornon-significant factors, and normally 32x2-1=63 dof total. However, during the replication experiment, four (4) experiments hasn't been achieved.What can I do with this situation, ? For these experiments, would it be better to put the average response, the same response than initial experiment (for which I have all the 32 results), nothing at all, or something else ? - Yannick Marcoux	*Considering that you have completed 28 out of 32 experiments in your L-32 design, you should assume the results to be the GRAND AVERAGE of the available results and proceed to calculate the factor effects/main effects. After you determine the optimum condition, verify the performance at optimum by running several samples at the optimum condition.Should you want, you can now pursue an iterative process (theoretical) to refine your estimate of the results you assumed. Using the grand average and factor averages of result, you can calculate (Yopt = Gd. Avg + ….) the results in the missing trial conditions. These new results then become the starting point for next iteration.* - RKR, 99-0413

Topic /Ref : Interaction & ANOVA (Ref : DOE-DG12-990420)

Question	Answer / Discussion
Is it possible to calculate an ANOVA for interactions between factors even if no column was assigned to this interaction ? If yes, how many levels will I have for interaction, if I have 2 factors with 2 level each ? (With an assigned column, I will get 2 levels of interaction, but without ?). And if I must consider the interaction column, but this column have been used for a direct effect, what can I do (Severity Index is interesting, but no sufficient...)? - Yannick Marcoux	*In order for you to calculate ANOVA terms for an INTERACTION, you must have a column reserved (sacrificed) for it.* *Interaction can be analyzed and tested from the results in two parts. (1) Test of presence (Presence does not necessarily mean it is Significant) and (2) Test of significance. The first one, that is, the test of presence can be done even if you do not have a separate column reserved for it. This is what the Severity Index tells you. So, what can you do with it? Just be aware of them, and may be, if possible, include them in future experiments. The test of significance, on the other hand, is done in ANOVA and can only be performed when interactions are placed in special columns.* - RKR, 99-0420

Topic /Ref : Non-linear Factor Behavior (Ref : DOE-DG13-990521)	
Question	Answer / Discussion

I used an M16(4^5) orhtogonal array to study 5 factors in 4 levels. I did data analysis for the optimization of analytical procedures. Furthermore, a third order polynomial model represnting response surface is established to estimate the effects for the factors with significant influences and to obtain the best optimization points. Then I did verification tests in two conditions, one in the optimum conditions which is obtained from main effects study and ANOVA (I) an the other in the optimum conditions which was obtained from polynomial (II). It is expected that condition II gives the better result than condition I, but it did not happened. I will be grateful, if you kindly let me know what caused that?

-Younes Leysi Derilou
Department of Chemical Engineering, Tarbiat Modarres University, Tehran 14155-4838, IRAN.

Your question relates to nonlinear factor behavior and comparison with an alternative approach (an analytical simulation using Main Effect data). Interesting question. I encourage you to look further into it.

Background review – When factors are studied at two levels only, you have no choice but assume that the factor behavior follows a straight-line. Consequently, the Optimum condition can only be predicted using the levels described in the experiment, as one or the other point will definitely be the desirable condition(Smaller or Bigger is Better). If on the other hand, you have factors at three or four levels, it allows you to join the Average factor effects at levels by a smooth curve (Least Square 2^{nd} order curve, quite commonly used). This is what you have attempted to do with the four levels of the factors in your experiment.

But just because you have been able to simulate a smooth curve that better represents the actual behavior, does not mean that it will predict any point outside the limits created by the original data points. In other words, the smooth curve may not necessarily have a point that is, say higher (in case of Bigger is Better quality characteristic) than the original points used to simulate the curve. You should be able to see the behavior clearly when you actually draw the two sets of graphs together.

- RKR, 99-0521

Topic /Ref : SPC and DOE (Ref : DOE-DG14-990629)	
Question	Answer / Discussion
I'd like to ask you for some questions because I am a new learner about Taguchi method. These are some of my questions: 1. Is it necessary using SPC before I implement Taguchi method in ceramic production N.B : I'm doing research in ceramic factory now and I want to know what is the optimum setting for the formula of ceramic 2. what is the strong reason for selecting number of level for each factors ? 3. In ceramic factory, what is the benefit of using Taguchi method ? - Xie Chuan Ming	*Here are my comments to the questions you asked:* *1. Should SPC be done before DOE?* *Quite the opposite. You should first attempt to apply Design of Experiment (DOE) in the development phase and before you do SPC. SPC can begin after DOE ends. The purpose of DOE will be to understand how each of your factors behave and determine a combination of the factor levels (included in the experiment) that produce the most desirable result. DOE will also tell you which factors are important and which ones are not. This information will help you decide which factors you need to control. You would also have a good idea about which tolerances you need to tighten, which ones you can relax, and about those factors which need not have tolerances at all, as they may not have any influence to the result. Naturally, you have much to learn by doing DOE before SPC.* *2. What are considerations for selecting number of levels?* *The main consideration for deciding whether you should have 3 or more levels for a factor is your knowledge about the nonlinear behavior of the factor. Obviously, two is minimum number of levels for a factor. Consider three, if you suspect strong nonlinearity. Remember that the number of levels will cost you in terms of overall size of the experiment. For this reason, you should stay with two levels unless you have prior knowledge about the factor behavior.* *The consideration about non-linear behavior will only applies to factor that are continuous. If the factor is discrete/fixed (supplier, containers, machines, etc), you may not have much choice but to consider as many levels as your experiment design array will accommodate. If you are unsure of what to do, prefer two levels for all factors.* *3. Is Taguchi Approach good for ceramic factory?* *It should be good for optimizing any process. You must find many processes in your ceramic factory that will benefit from DOE/Taguchi in PROBLEM SOLVING and in PROCESS OPTIMIZATION studies. I do not have direct working experience with ceramics. So, it is difficult for me to be specific. But I have read DOE applications in ceramics and had seminar attendees from that part of the industry.* *Hope this is helpful to your application projects.* - RKR, 99-0629

Topic /Ref : Factor Level Adjustment for Interaction (Ref : DOE-DG16-990728)

Question	Answer / Discussion
I conducted experiment test for the purpose of finding optimum setting factor that significant in making glaze of ceramic. In addition, I used 2-LF and L8 OA cause from brainstorming session, I identify 5 factors and 2 interactions (AxB) and (AxC). The problem is from average analysis, factors that are significant concists of A2, B2 and E2. Meanwhile from S/N analysis, factors that are significant concist of B1,C2, E2, and interactions A and B. So, in conducting confirmation test, what level should I choose for factor B ? Besides, from S/N analysis there is interactions between A and B, so how we determine what is the best (I mean , is it A1B1 or A1B2 or A2B1 or A2B2) ? Is it based on S/N value (the greater the better) ? -Xie Chuan Ming	*Your question deals with priority of S/N analysis over Standard analysis and about interaction.* *Since you were able to perform S/N analysis, I would assume that you have more than one-sample results per trial condition. As always, when there are more than one column of results, that is, you tested more than one sample for each trial condition, you must perform and rely on S/N analysis. Qualitek-4 allows you to perform analysis both ways for convenience. But you should always depend on the S/N analysis even when the two types of analysis do not produce the same conclusion about the factor effects and optimum conditions.* *Why should you rely more on S/N analysis?* *As you are aware, S/N incorporates both MEAN distance from the target and VARIATION around the target. Where as, Standard analysis primarily makes use of the MEAN values.* *Regardless of the type of analyses, however, significant interaction must always get preference over the factor level selections without considerations of interactions. This means that, when interaction suggests a level, you should select that as part of your optimum condition whether it is there or not. In cases where the level selection of a factor based on separate interactions are in conflict, it is better to select the factor level that produce the best expected performance.* *Remember always to consider greater values of S/N for Optimum as well as interaction studies. Higher values of S/N is always desirable no matter the Quality Characteristic (QC) of your project. The different QC affects S/N analysis by producing difference in Mean Squared Deviation (MSD) values which has a different value for different QC.* *[Note:The final decision about optimum levels for factors whose interaction information is available, must be corrected based on interaction data, particularly from the plot of presence of interaction (two-line plot). I recommend you to study the section on INTERACTION in my text or download free literature from our sites (www.nutek-us.com/wp-s4d.html)].* - RKR, 99-0728

Topic /Ref : Quality Loss Function & Process Capability Index (Ref : DOE-DG18-990915)	
Question	Answer / Discussion

I have some questions about Taguchi method, and could you give some explanation

1. What is the benefit and the weakness of using Taguchi Method ?

2. If the process of production has already been capable (indicated by Cp and Cpk), do we still have to implement Taguchi method ?

3. We do design of experiment by Taguchi method in laboratory scale. But sometimes laboratory scale different from the actual (I mean production scale), so how about that ?

4. Is there any relationship between Cp index and Quality Loss Function since both are measured based on variations around target value ?

OK,thats all and thanks for your attention.

-Xue Chuan Ming

Here are answers to the questions you asked.

Your questions are thought provoking and deserve detail explanation. Hope this brief discussion will be of some help to you.

1. What is the benefit and the weakness of using Taguchi Method ?

The major benefit of the Taguchi Approach is in that it a STANDARDIZED approaches for PLANNING, DESIGNING, and ANALYZING experiments. Consequently, it is much easier for industrial prctitioners to apply the technique without background in statistical science. Lasting benefit is also derived when Dr. Taguchi's principles of ROBUST DESIGNS are implemented. His recipe to address the variability causing 'noise factors' by way of OUTER ARRAY design and use of Signal to Noise Ratio (S/N) is a revolutionary strategy to build quality into products and processes.

Weaknesses, if any, mainly stems from lack of application expertise. In systems where factors heavily interact, careful use of the orthogonal arrays will be required.

2. If the process of production has already been capable (indicated by Cp and Cpk), do we still have to implement Taguchi method ?

Yes. Reducing variation (increasing Cpk and centering distribution) should be a never-ending process in the manufacturing activities. By using DOE/Taguchi, the variation in the process performance can be continually reduced. This can be achieved by making product/processes insensitive to the influence of the uncontrollable variables. Reduction in variation will result in increased customer satisfaction and reduced warranty cost.

3. We do design of experiment by Taguchi method in laboratory scale. But sometimes laboratory scale different from the actual (I mean production scale), so how about that ?

The laboratory or pre-production parts would always differ from the production. This is a common problem in many manufactured products. Attempting to 'do it right the first time', there is no way to get around it. You must still pursue design optimization before production as long as you can expect that the TREND of improvement will be the same. In other words, do not expect a correlation of improvement in discrete terms, but expect the same relative improvement. In laboratory, or with pre-production components, go for QUANTUM improvements.

4. Is there any relationship between Cp index and Quality Loss Function since both are measured based on variations around target value?

There is.
Cp, Cpk, MSD, S/N, $Loss, etc. all are related to the AVERAGE, STD. DEV., and SPEC. LIMITS. Thus, when variation around the target is reduced, Cp, Cpk, and S/N go up, and $Loss and MSD go down. If you look into how each are defined, you will be able to establish the analytical relationship. I find it convenient to always work with Average & Std. Dev., represent them graphically first, and then calculate other entities, as you want.

- RKR, 99-0915

Topic /Ref : Noise Factors and 3-Lvel Factor Designs (Ref : DOE-DG19-990919)	
Question	Answer / Discussion
I am a graduate student at the University of Arkansas and i am working in the design of experiments. I have a doubt in setting up the OA table. In my setup, I have to include 4 factors each at different levels .Typically the levels are 5, 3,3,3. Which OA table should i include and whether I should follow a psuedo-factor design. I am not clear on this. I request you to clarify my doubt. -Sundaram Narayanaswami	*In this mail, I will respond two separate questions (see letter below).* *Q. How to treat Noise Factors* *Factors that are difficult or uneconomical to control are the primary sources of variation. Dr. Taguchi calls such factors as NOISE factors (no relation to literal noise). For experiments designed to study and reduce performance variation, experimental samples need to be repeated by exposing them to the influence of the noise factors. Any scheme to create the conditions of the noise is referred as the OUTER ARRAY. When there are more than two noise factors involved, you will find it convenient to use one of the standard orthogonal array to describe the condition of the noise factors for repeating test samples in each trial condition.* *It is not necessary that you always use an array to include the Noise factors in your experiment. Often, to keep the number of samples to a minimum, you may want to determine the two extremes of the Noise conditions, and run multiple samples under each of the condition.* *Results of multiple sample experiments should always be analyzed using S/N. This is true regardless of presence of an Outer array.* *Q. How to design experiment for three 3-level factors and one 5-level factor.* *You will have much easier time designing experiments (using Tgauchi Orthogonal arrays, L-4, L-8, L-9. . . . L-32) when the factor levels are 2, 3, or 4. If you could limit all four factors to 3-level, you would be able to design your experiment using an L-9.* *If you must study all 5 levels of one factor along with the other 3-level factors, then you have to do some array modification. You will start with an L-18 (one 2-level column and seven 3-level columns). Combine the 2-level column (column 1) with one of the 3-level column to form a 6-level column. DUMMYTREAT this column to a 5-level column (replace all 6's to 1). Assign the 5-level factor to the 5-level column just created and three 3-level factors to three of the six 3-level columns. You will leave the three columns UNUSED, but will need to run all 18 trial conditions.* *It's hardly worthwhile to suffer such penalty only to try two extra levels. I recommend you select the tree levels out of five and run an L-9. If necessary repeat L-9 including the other levels.* - RKR, 99-0919

Topic /Ref : Qualitek-4 (Ref : DOE-DG20-990927)	
Question	Answer / Discussion

I have briefly tried using the demo version of your software and it was quite surprised by it. As a Masters student at Brunel university (UK), Advanced Manufacturing Systems, I was thinking of carrying out a dissertation using Taguchi Methods to find out the ideal number of manpower required for maximum productivity in a rail transport environment.

I would be interested in finding out your views on the possibility of using Qualitek software. Whether case studies already exist, and the quality criteria used in order to reach conclusions that the required workforce number is the ideal one to accomplish the task. Difficulties encountered etc.

-Vincent, UK

I do not have application experience in the specific area you want to pursue your research. Perhaps some of our members will respond to your needs. It appears that you could benefit from some information on how to identify factors for the study and how to define and determine criteria of evaluations for your objective.

Members, please HELP Vincent.

As far as the use of Qualitek-4 DEMO software is concerned, you should be able to utilize it for your project as long as the experiment is designed using L-8 array, regardless of the areas of application. Should you need some help in exploring Qualitek-4 software, I'm enclosing a note attached at end of this letter for your reference (www.nutek-us.com/wp-q4w.html).

- RKR, 99-0927

Topic /Ref : ***Why*** Do DOE/Taguchi (Ref : DOE-DG24-000405)	
	Answer s from members

Recently I received a call from an engineer of a large manufacturing company. She was wondering if I could help her with reasons why her company should go for Taguchi approach (which she proposes) as opposed to the classical method. Confronted with such proposition, I generally offer some features that are attractive to me in Taguchi approach, and avoid direct comparison of the two methods. I try to avoid comparing the two methods for two reasons. First, being an engineer, I do not know enough about the statistical science behind Design of Experiment. Second, being in the business of providing services in Taguchi Approach, I feel it is self-serving to speak evils of classical DOE. ***So I wonder if you all will help me out?***

I assume most of you are involved in DOE and/or Taguchi Approach, one war or another. Wonder if would take moment to ***write a sentence or two*** *to let me know your reasons for preferring to use the method you use (use notation C-DOE for classical, T-DOE for Taguchi approach).*

Here is what I will do with the information you provide information.
Display your response in a web site for all to refer
Post your name and e-mail address if you specify (optional)

[Your answer could be brief and you need not reveal your name and e-mail address. But if you do indicate your name, I will post it with your response.]

- RKR, 00-0405

To me, Taguchi is attractive because of two reasons:
1) It confines the experimental space
2) Economics

The down side is that at some point of time, you should be bold enough to make the giant leap (or at least what seems like a giant leap) to implement the findings.

- Sogal, sogal@ix.netcom.com

Having done some extensive research in the area of Experimental Design, there are no hard and fast rules for the choice of experimental design for a particular problem. It is not a good practice to stick to one approach for solving all process optimisation problems using Taguchi methods of Experimental Design. However Taguchi approach is the best approach for those organisations who are new to experimental design area due to its statistical or mathematical simplicity (degree of statistics involved). It provides a systematic approach to experimentation so that you can study a large number of variables in a minimum number of experimental trials. This will have a knock-on effect on experimental budget and resources. Another reason why Taguchi approach is better over Classical approach is the concept of achieving robustness in the functional performance by inducing the presence of noise factors during the experiment. It is a good starting point towards continuous improvement of process/product performance. However it is simply not the best optimisation technique available today. Taguchi would not be able to provide us the true optimal value of a factor setting. It merely tells us which is the best level for a factor setting from the levels chosen for experimentation. In my view, the choice of experimental design is based on :

1. the degree of optimisation required for the response or quality characteristic of interest
2. statistical robustness and validity
3. complexity of understanding the choice of designs
4. cost and time constraints
5. ease of implementation
6. design resolution

Hope this helps. You may add my contact name and e-mail address for further discussion.

DR JIJU ANTONY, INTERNATIONAL MANUFACTURING CENTRE UNIVERSITY OF WARWICK , e-mail: Jiju.Antony@warwick.ac.uk

“The classical DOE is more concerned with statistics and model creating rather than engineering solution. For this reason, it is not generally accepted in industrial environment. In other words, engineers consider classical DOE as a difficult tool for practice.

Taguchi DOE does not require extensive and rigorous scientific and statistical background (knowledge), instead engineering solution is preferred. So this approach is more understandable for practical engineers. The Method is relatively easy to implement and understand. It gives good results in practice.”

- Pavel Blecharz, Email: pavel.blecharz@vsb.cz

“Response Surface Methods and other approaches are quite suitable for eg. research studies where often the influence of the various factors to be investigated are not well known. Here often quite a number of experimental trials need to be done as one ventures into somewhat uncharted territory. On the other hand in practical engineering problems the problem under investigation often relates to "fine tuning" of a process where the people involved have a reasonable "feel" for the process. The Taguchi approach is quite suitable for this purpose. Often researchers make use of Taguchi Methods for screening a large number of factors to narrow it down for more intensive study by eg RSM.

Taguchi Methods are relatively easy to grasp by co-workers on the shop floor as compared to the more statistically intense alternatives and aids their buy-in.” -WR, South Africa

When approaching a comparison of two viable alternatives, you should always "appear" to take the high road while serving your own interests. Expound on areas where "both" methods are viable and comparable, but then identify areas where the "preferred" element is clearly MORE advantageous to the user, creating the both very good, but one obviously better illusion.

Use two different "obviously better" scenarios:

When the field of use is outside of the "common" area where both products are viable; in essence, this method illustrates a better solution for your specific use; "Both can be viable in THAT type of application, but in these areas, the Taguchi method offers much more"

When the field of use is within the "common" viable application arena; this identifies only specific advantages within the field of use.

"Both are viable in this arena, but the specific advantages in this area are....."

By playing the odds, one half of the prospects will fall within the common field of use (the advantages there must be very specific - showing your expertise), but the other half falling outside of the portrayed common field

of use, making the "assumptive" decision obvious to the reader/receiver when presented in this manner.
-CV, E-mail: <cveach@winspc.com>

"As a consultant and trainer in the areas of Statistics and Statistical Process Control I am confronted, on a regular basis, with this question of whether to suggest a Classical Design of Experiments or to use the Taguchi methods . The question becomes quit easy to answer. If the customer has minimal knowledge of their process with a large number of factors to investigate or has more than two levels of each factor to examine the answer is Taguchi.

Three reasons:

Reduces Time - analyze only the interactions that you believe truly exist,
Reduces cost - reduction of all but necessary interactions,
Classical DOE does not (normally) accommodate more than 2 levels of each factor nor lend itself to mixed level designs whereas Taguchi does.

There are more reasons but I'll keep this reply short." - Karyn Heydt

Topic /Ref : Confidence Interval (C.I.) (Ref : DOE-DG25-000417)

Question	Answer / Discussion
I want to ask you something more. It's about Confidence Interval (CI). I read that CI was calculated in three cases : 1. For a factor level. 2. For a predicted mean 3. For a confirmation experiment I'm confused in point 1, because i don't understand what is the use of this calculation. But point 2 and 3, I think they're for comparing so we know if our experiment is reproducible or not. But point 1 I can't analyse that. So, I hope you can tell me what's the use of point 1 and tell me if my opinion about point 2 and 3 is true. Thank you Sir. I'll wait for your reply. Sorry Sir, my English is not good enough. Miranda in Jakarta	*Hi, possibly this will explain :* *Point 1: If you take the average of the responses for the level of a factor or combination of factors, you can set a confidence limit on the response. You might want to do this because you might want to use a certain combination of factor levels even if they are not optimum.* *Point 2: The above is the same answer for this one.* *Point 3: There is no such thing as the "confidence for a confirmed experiment." Possibly here you mean the response from a confirmation experiment, which you can set a confidence limit on.* ***- Leonard R. Lamberson*** *The confidence interval (C.I.) at a confidence level, expresses the limits within which the value is expected to be. Consider that the average effect A1 = 80, and C.I. at A1 is +/- 5 at 90% confidence level. This means that when several experiments are carried out (perhaps by different people at different times), the value of A1 calculated from the experimental results will be within 80 +/-5 nine out of ten (90%) times.* *Think of scenario where as a group experimenters/team brainstormed a project and identified a set of factors and their levels for the study. Now if participants from different parts of the organization choose to design and carry out the same experiment independently (using the same factors and levels), their experiments will be of the same size (say L-8 or L-12, etc), but the individual trial conditions may not necessarily be the same. In such situation, only the first trial condition will be the same, all other will not. Naturally, the results of all except the first trial condition will be different. When the results of all such (different) experiments are analyzed, the factor average effects and the conclusion about the optimum levels, however, are expected to be the same (within limits). The average effects for factors (at any level), from all experiments are expected to be within the C.L. This is the end use of the C.L.* *Just as the C.L. for factor level, the same for performance at the optimum condition helps validate the analytical prediction when the mean of the confirmation test samples falls within the limit.* - RKR, 00-0417

Topic /Ref : ANOVA & Percent Error (Ref : DOE-DG26-000430)

Question	Answer / Discussion

I'm confused about percent contribution error. The theory wrote that, if the percent of error <15%, it means that no important factor have been omitted from the experiment. If it high (<50%), it assumed that some important factors have been omitted or conditions were not well controled or there was a large measurement error.

So, if my percent of error between 15-50%, said it is 30%, so what is the meaning of 30% error contribution in my experiment ?

Thank you Sir, I'll wait for your reply as soon as possible. Bye.....

Miranda in Jakarta

Perhaps you are referring to the %error in the ANOVA table.

The numbers (% values) in this column represent the RELATIVE PERCENT OF INFLUENCE TO THE VARIATION OF RESULT. It should not be termed as CONTRIBUTIONS. The term contributions express the individual factor additions to the expected performance at the optimum condition.

Meaning of the error %:

Error % influence is meaningful only when the error degrees of freedom (EDOF) is non-zero. If EDOF is zero, error % must always be zero (if the math is correct). This, however, does not mean that there is no experimental error. It simply indicates that there are no provision in the experiment to capture the experimental error.

Conventionally, error % has been considered as the error associated with carrying out the experiment (experimental error). But it is not only the experimental error (within experiment error and between experiment error). The % error represents combined effects of three sources: (1) Effect of all factors not included in the experiment, (2) Effect of NOISE factors, and (3) any experimental error. When the designed experiments are carried out under well-controlled parameter setting, it is generally the first two sources that account for the % error. Thus when you see larger magnitude of %error, it may be due to the fact that the experiment did not include a important factors, or that the influence of factors other than those included in the experiment is great. In short, the % error represents the relative percent of influence due to factors other than those included in the experiment. For sure, high percent of influence of error term is not necessarily a reflection of how well the experiment was carried out, and nothing the experimenter should be alarmed about. There is no fixed limit of percent error, which makes an experiment better. Each factor must be tested for significance individually before it can be considered insignificant and POOLED. Percent influence of factors and interactions studied in the experiment can be significant regardless of the magnitude of error %.

Good luck in your completion of the coursework this year.

- RKR, 00-0430

Error % gives us some information, but not alone. F-statistics for factors give you additional important information. If F for factor is

	bigger than value from F-table (given confidence, say 90%), you can rely on factor effect, i.e. factor is significant (Error is included in calculations by means of denominator -Ve). In addition, exact value of error % may vary in accoradnce with number of pooled factors. One may pool smaller number of factors, let experiment looks better (smaller error %)- but it is not good approach. So it is ALWAYS recommended to pool factors as far as DOF of pooled factors is equal about 1/2 of total DOF. No matter how big is error %. If you are doubt (pool-unpool), use F-test when having some DOF disposable. Best regards, Pavel Blecharz, Ph.D

Topic /Ref : Overall Evaluation Criteria (Ref : DOE-DG27-000427)

Question	Answer / Discussion
I receive your e-mail on Taguchi Methods regularly and I find it very much useful. I have a small query and I would appreciate if you could throw some light on that; "If there are more than one quality parameters and the optimal settings as obtained by DOE are distinctly different for the various quality parameter, how does one deal with such a situation?" Say, in case of a welded joint, Strength and %Elongation are the two quality parameters (both are Larger the Better type). The optimal settings as obtained with DOE are as under; STRENGT: A1, B2, C2, D2, E1, F1, G1, H2 and I1 % ELONGATION: A1, B1, C1, D1, E2, F2, G1, H2 and I1. Which setting should be selected? -Ajay Likhite	*I'm glad you posed this question. Your situation highlights the need for the capability to analyze results with an Overall Evaluation Criterion (OEC), which is a standard capability in Qualitek-4 software.* *When there are multiple project objectives that are evaluated by separate criteria of evaluations, you can always analyze results (each criterion evaluation as you did) separately and identify the optimum factor levels. However, there is no guarantee that the separate analysis all will produce the same factor level combination. Since you only have option specify one single combination for the optimum design of your product/process under study, you have conflict at hand as described by your experiment.* *It is possible to determine an objectively compromised factor combination when you determine the optimum condition by analyzing the results created by combining different evaluations together, instead of analyzing each evaluation separately. The combined evaluation (result of each test sample) is called the OEC, which is a single index representing the performance of a sample under all evaluations.* *When formulating OEC, one must recognize that each evaluation may have*

units of measurements that are different. Each evaluation representing performance under different objectives may also be of different quality characteristic (QC, bigger, smaller, nominal). Finally, the single index must incorporate the relative weight of the individual criteria of evaluations. It is safe to assume that not all objectives carry the same weights. OEC formulation used in Qualitek-4 attempts to create the result that incorporates attributes of all objectives applicable to the project.

You can see how OEC is formulated and used for analysis by examining POUND.Q4W experiment file included in Qualitek-4 DEMO program. This experiment file represents how the recipe for POUNDCAKE baking process is determined for cake evaluated under three different criteria. To study how results (which are OEC) formulated, select OEC from EDIT menu in the Experiment Configuration screen.

When you have multiple criteria of evaluation, I recommend the following steps:

Analyze results separately for all objectives
Try and make best compromises of factor levels intuitively (judgement)
Formulate OEC/results
Analyze results using OEC and examine the optimum condition. Rely on optimum from OEC.

You can read up on OEC in my textbook. Also, find some descriptions in our site: www.nutek-us.com/wp-oec.html . This topic is discussed at length in my next book to be published by John Wiley in 2000-2001.

- RKR, 00-0427

Topic /Ref : Higher Factor Levels (Ref : DOE-DG05-000420)	
Question	Answer / Discussion
How would increasing the number of levels used for a factor affect the accuracy of the prediction? For example would a 4-level 6 factors experiment give better results than a 2 level 6 factor experiment? -Chris Thompson	*There are several attractions for higher than two levels for factor. As known to all, for a factor to be a factor under study, it must have two levels. When all factors are at two levels, it allows you to study them with smallest number of experiments. However, studying factors at two levels does not indicate information whether the factor influence is nonlinear or not. If non-linearity is present, the optimum factor level might indeed be at a point between the two levels, which will not be identified when two levels are studied.* *6 2-level factors can be studied by 8 experiments (L-8 Array)* *5 4-level factors can be studied by 16 experiments L-16 modified Array)* *6 4-level factors will require 32 experiments* *4-level factor experiments will be better due to the following reasons:* *-Provide clear information about non-linear influence effect of the factor.* *-Allows study of current level (if known), along with other values of the factor on both sides of the current factor value.* *-Increases chance of finding true optimum by selecting the value of the factor for optimum performance.* - RKR, 00-0420
	There are some situations in industry, when use of higher number of levels is neccessity. Beyond study of non-linear effects, discrete factors may require more levels, e.g. factor=lubricant, one wants to test 3 types of lubricants an factor has therefore 3 levels. But generally, good approach is like this: - First, test factors in 2 levels. Only if you know about non-linear effect, consider about more levels. But, when looking for optimum, non-linear effect is important when curve has maximum (minimum) inside given range for testing. -Select important factors (approx. 1/2). From selected factors choose the factors with non-linear effect (typically small number, so L-9 may suffice) and test in 3 level experiment. -Select significant factors, say from 4 factors select 2. Take remaining 2 factors and test in 3 new levels again. As far as new levels give better results. Once response remains the same, you have an optimum. Usually, such approach requires smaller number of experiments than design with more levels (say 4) from the start.

Good luck,

- Pavel Blecharz, Ph.D.

Good Experimenters generally try to reduce the size of the experiment by studying a large number of factors in a small number of trials. If you study factors at more than two levels, then there must be some justification on why do you need to study all the factors at more than two levels. If you have more than five factors, it is good practice to find out whether you need to include all these factors in one large experiment. I would advocate "screening experiments" in such circumstances, where the objective is to find out how many of the factors selected from brainstorming have a real impact on the performance characteristic. For screening experiments, use factors at two levels to separate out the most vital ones from the trivial ones. Once you reduce the number of factors to a manageable number, perform smaller sequential experiments for optimisation. One may go for higer levels, if non-linearity is suspected. Bear in mind, the number of levels increases the size of the experiment. It is advisable to use Response Surface Methods (e.g. Central-Composite method)for determining the optimum condition. RSM gives a better picture on where do you stand and how far you are from optimum performance. Hope it helps. Should you have any queries, please do not hesitate to contact me.

- Jiju Antony

Topic /Ref : Loss Function (Ref : DOE-DG29-000714)

Question	Answer / Discussion

I want to ask about Loss Function. L(y) = k(y-m)^2. I'm about k. k=cost coefficient. k = (Average cost/tolerance^2). Average cost can be cost of rework, replacement etc. The tolerance is confusing.

If the characteristic is nominal-the-best, the tolerance is clear. Example my specification is 25+/- 5. It means LCL is 20 and UCl is 30. So i put 5 as tolerance in calculating k. If Average cost is 0,2 and tolerance 5, k=(0,2/5^2) = 0,008.

if the characteristic is larger-the-better, I have data from my company, the target specification is minimal 4. So can I use 4 as tolerance in calculating the k. So the answer is k = 0,2*(4^2) = 3,2.

If the characteristic is smaller-the better, and the maximal is 1000. So k = (2/1000^2) = 2x10exp-7 or 0,0000002.

My question : for point 2 and 3, is the tolerance for calculating the k true ? So we can tolerance get through the minimum and maximum data, or we must find and ask tolerance from company, or there is some formulas to calculate it. This is important for my loss function calculation. Thank you Sir, I'll wait for your reply as soon as possible.

-Miranda in Jakarta

(*I'm not sure this issue has been discussed to your satisfaction before. It's been quite a while I received this question and cannot be sure if I had responded you. Forgive me if this is a repeat.)*

It seems you are pretty clear about the Nominal characteristic and the Loss function. L =K(yo – y)^2 works well when you calculate K from the yo – y =Tolerance value. This equation however cannot be easily manipulated for the BIGGER or SMALLER characteristics.

For SMALLER and BIGGER situation, you should use the loss expression as L = K (MSD). By knowing the current loss, say L1 and the current status of MSD (this can be found from known S/N value or by collecting samples at the current production). If SN1 in current status is known then MSD1 becomes, MSD1 = 10^(-SN1/10) since S/N = -10 Log (MSD)

From know MSD = MSD1 and L = L1, K = (L1) / MSD1

Now that you have determined K, the new loss (L2) can be calculated when the new MSD (MSD2) is known.

That is L2 = K (MSD2)

(The tolerance will not be needed in this manipulation)

When using Qualitek-4 software to calculate loss, you will use the GENERAL case option under the Loss capabilities.

- RKR, 00-0714

Topic /Ref : Title or Key Words (Ref : DOE-DG30-000713)	
Question	Answer / Discussion

I want to use Taguchi Method in my project which is about "Modification of Alkyd resin with styrene",

I'll be very obliged to you if you please check my design and tell me the wrong points of it.

My Design :

Factors:

1. A: Temperature : 2 levels, A1, A2
2. B: Reaction Time : 2 levels, B1, B2
3. C: Concentration of solvent : 4 levels, C1, C2, C3, C4
4. D: Type of Initiators: 2 levels, D1, D2
5. E: Concentration of initiator type one (D1), 4 Levels, E1, E2, E3, E4
6. F: Concentration of initiator type two (D2), 4 Levels, F1, F2, F3, F4

Interactions:

1. A*B

Design:

I used Branch design and mixed factors levels simultaneously,

I chose L16 array and select columns (4,8,12) and (5,10,15) for creating new columns for 4 level factors C and (E,F).

I put factor D in column 1, factor A in column 6 , factor B in column 11 and the interaction between them (A,B) in column 13.

The Modified L16 Array is in the attached HTML file.

-Amir Hossein Bahri,

Your experiment includes three 2-level factors (A, B, and D), three 4-level factors (C,E, and F) and an interaction between factors AxB (both are 2-level factors).

The columns you selected for your design looks alright. However, I'm not sure about the modified columns you sent me as the attached document. I recommend you to follow the guidelines below.

You will need an L-16 orthogonal array for your design. Since the L-16 array comes with 15 2-level columns, you will need to upgrade THREE columns to make THREE 4-level columns (for factors C, E, and F). As you are aware, to prepare a 4-level column you will need to combine THREE 2-level columns that are part of an independent interacting group of columns (IGC). You can select threes sets of IGC as 4-8-12, 5-10-15 and 7-9-14. You must follow the standard procedure to combine the set of three columns to create the 4-level column. It is a common practice to prepare the first column in the set as the 4-level column and designate the other two as UNUSED. For example, when you prepare a 4-level column using 4-8-12, call the first column (col. 4) as the 4-level column and identify columns 8 and 12 as UNUSED. (Reference: A primer on the Taguchi Method – R. Roy)

To design your experiment, assign the three 4-level factors (C, E, and F) to the newly created 4-level columns (columns 4, 5, and 7). Assign factors A to column 1, factor B to column 2, and reserve column 3 to study interaction between AxB. The remaining 2-level factor can be assigned to column 11 and columns 6 & 13 are left as UNUSED.

- RKR, 00-0713

Topic /Ref : Areas of Use of Taguchi-DOE (Ref : DOE-DG31-000831)

Question	Answer / Discussion
I visited your website which contains a lot of useful information about DOE. Thank you very much. We are an automobile design company and I am searching on in what cases we can make use of this powerfull technic. I have gathered some information about DOE, but I don't know exactly in what kind of problems I can use them and what is the difference between simulation technics and DOE at all. Could you please kindly give me some information about what would be the use of DOE in designing an automobile, or introduce me some informative sites in this regard. Thank you very much. Majid Mashayekhi Design Engineer Automotive Industries Research and Innovation Center, Iran	*Let me address the questions you asked in the following manner.* *Where to use DOE/Taguchi?* *You should think about using DOE whenever you have options to vary performance by adjusting more than on thing. In other words, you would benefit from DOE in situations where you suspect there are multiple variables (parameters, factors, inputs, etc.) influencing the outcome. Generally you study products or processes by conducting experiments with production representative hardware (when available). But in absence of hardware, such experimental studies can be done with analytical simulation of the performance of the product or process under investigation. You should consider using DOE in DESIGN activities to OPTIMIZE DESIGNS and to make your designs ROBUST. The term robustness would refer to making products and process insensitive to the influence of factors you cannot control or do not want to control. In production environment, DOE can be a highly effective too to structure your PROBLEM SOLVING STUDIES and yield solutions most economically.* *How to use DOE in concept designs?* *When your design is not yet complete, obviously, you cannot make parts or conduct experiments. In such situations, if you happen to have analytical simulations for advance studies of stress, vibration, failure modes, etc., insist on using DOE to most economically optimize the designs and build quality into the products. Building quality into products, in this activities will the achieved by selecting design parameters that is expected to produce performance with least variations.* *For more information on the subject and self-teach the subject, you may benefit from my new book expected to be published in a few months. This book will carry a CD-ROM, which will contain solutions to over 240 examples and exercises in the book. You can find information about the book in WWW.AMAZON.COM .* *New Book (coming soon)* ***Design of Experiments Using the Taguchi Approach: 16 Steps to Product and Process Improvement*** *by Ranjit Roy (www.nutek-us.com/wp-txt.html)* - RKR, 00-0831

Topic /Ref : Multiple 3-Level Factor Study (Ref : DOE-DG32-0925)	
Question	Answer / Discussion
This is the second (if not the third) letter I am writing to you regarding Taguchi Methods, for all of which I have received your kind replies. As part my of work, I design culture media for production of microbial products, previously by ONE FACTOR AT A TIME, and now by TAGUCHI METHODS, using orthogonal arrays. I have encountered situations in which I have to choose between three factors, and at the same time at three different levels. For example I want to study the effect of three (or more) different carbon sources (as nutrition for microorganisms), like glucose, sucrose and starch, and each of these compounds should be added at three (or more) different concentrations, namely 10, 15 and 20 gr/l. How should I design the experiment, where I can explore the main effects and interactions, in the same time? I will impatiently looking forward to receiving your kind answer. Best regards. Dr. Mehrdad Azin Biotechnology Research Center, IROST	*Your project involves One 4-level factor and four 2-level factors. You also suspect several interactions and wish to study them. For your experiment design you were thinking about an L-32 array.* *For your situation, my recommendation will be that you ignore interaction at first and keep your experiment small. You can use a modified L-8 to design an experiment to study one 4-level factor and four 2-level factors. You will, of course, modify the standard array to accommodate the 4-level factor (combine the first three 2-level columns to create a 4-level column). After you carried out the experiment, analyzed results, and determined the optimum condition, run confirmation experiments. If you do not confirm, then considering repeating the study. This time include only the significant factor and a few suspected interactions in your study.* *For all your experiments designed using the L-8 array, you can use Qualitek-4 DEMO software without cost. You may also have your school library procure my new book shown below. This text will have details about how to modify an array.* *New Book (coming soon)* ***Design of Experiments Using the Taguchi Approach: 16 Steps to Product and Process Improvement*** *by Ranjit Roy (www.nutek-us.com/wptxt.html)* - RKR, 00-0925

Topic /Ref : Taguchi Vs. Other Types of DOE (Ref : DOE-DG34-000925)

Question	Answer / Discussion

Could you tell me what method is similar to Tagchi method in some way and
differ in others ?

I appreciate for your answer.Please do not ignor my questions. -Park, Chi H Mr IMMC

Comments:

There are mainly three approaches to design an industrial experiment - Taguchi, Classical and Shainin. The last one is not as common as the first two ones. However shainin's approach to identify the key or critical components in a system, multivari charts to understand the key components of variation, etc. have proved to be successful in a large number of organisations. Taguchi approach to experimental design is widely used by many industrial engineers in organisations for process trouble-shooting, optimisation problems and of course for rapid process understanding. However some of the approaches (especially statistical analysis) within this methodology is heavily criticised by many western statisticans. Having mentioned these, Taguchi methods have been highly successful and is essentially a good starting point on the journey to process optimisation.

Classical Design of experiments is similar to Taguchi with the experimental layout but generally use more powerful and robust analytic methods so that more valid and objective conclusions can be drawn. It is advisable to start with Taguchi and then perform more powerful methods within classical approach (e.g.: Response Surface methods) for greater optimisation. Should
you need more information with the similarities and comparisons, please do not heistate to contact contact me. Good luck!

-Dr Jiju Antony

Similarity *– The simpler form of experiment design in Taguchi technique utilizes orthogonal arrays specially created by Dr. Taguchi. The orthogonal arrays are same as the smallest fractional factorial (a fraction of the full factorial, which represents all possible combination of the factors under study). So, when you are dealing with simpler experiments (say, 7 2-level factors), you would do things very similar by classical design of experiment.*

Differences – In Taguchi method, things are done quite differently when it comes to analysis (uses Signal-to-Noise ratios), particularly when you are dealing with effects of uncontrollable factor. When it comes to treating the effects of uncontrollable factors (noise factors), Dr. Taguchi showed a new way of incorporating effects of noise factors by using outer array. His concepts looking into the effects of un-quality (lack of quality) and its quantification into monetary units by use of loss function is also new to the practitioner.

There are lot more you need to learn on these issues. I recommend that you search the web (use Excite, Webcrawler, etc.) to find and study literature available free. I also urge our readers to comment on these items. Write to the questioner directly with a copy to me so that I can forward to all in the discussion group.

- RKR, 00-0925

Topic /Ref : Test Sample SIze (Ref : DOE-DG35-001207)

Question	Answer / Discussion

I am about to be involved in a design of experiments project with a local company. The company people are trying to understand the the importance of replications in experiments. What is not sure at this stage is about an equation to rely on calculating the number of replicates. is there any difference between the sample size (in the context of experimental design) and number of replicates which you take during the experiment? If so, what is the fundamental difference? If someone could provide a useful equation for calculating the number of replicates, that would be great !!!

Many thanks Ranjit. If you know the answer, please get back to me soon.

Regards

-Jiju Antony

The benefits of multiple sample tests are primarily two. First, without it, information regarding variation in the performance cannot be detected. Second, larger sample data increases the confidence in the conclusions derived from analysis of the experimental results. But how many is good enough and is there an expression that quantitatively relates the benefit caused by the increased number of samples?

Increased number of samples in each trial condition increases the degrees of freedom (DOF) of the error term (Error DOF = number of results in the experiment – total DOF of the factors). This in tern assures higher confidence level in the calculated percent influence. Unfortunately, the expression for calculation of confidence level in terms of the information derived from the experimental data (sums of squares, F-ratios, etc.) is too complex for this discussion. Instead, the expression that can be reviewed by most is the expression for confidence interval (C.I.) for a given number of test samples (confirmation test).

The confidence interval when only a finite number of repetitions are planned is

*Confidence Interval: C.I. = +/- Squared root of [($F(n_1,n_2)$ x V_e x(N_e + N_r)) /(N_e*N_r)]*

Where $F(n_1,n_2)$ = Computed value of F -ratio with n_1 = 1, n_2 = error DOF
V_e = Error Variance N_e = Effective number of replications. N_r = Number of repetitions

In the above expression, as Nr increases, it affects all the quantities involved (see expression for all quantities in any textbook on the subject or Nutek seminar handout). Bottom line is that, with increase of number of samples, the C.I. band will be narrowed, or for the same C.I. width, the confidence level would potentially increase.

Hope this gives you enough leads for further investigation.
- RKR, 00-1207

Topic /Ref : Benefits of Replication (Ref : DOE-DG36-0 010115)	
Question	Answer / Discussion

x

x

I don't know if this helps in the discussion about the number of replicates, but I'm going to give it a try.

From my understanding, the number of replicates first depends on whether you are in the screening stage or are in the final stages of mapping the response surface of the active factors. Dr. Donald Wheeler's book on DOE discusses the following in more detail, and my comments are based upon his perspective.

My comments are based on memory, as all my DOE texts are back in my work office, and I'm writing from home on a Saturday morning.

During screening, replication is automatically provided using the Plackett-Burman approach during the process of reflection and picking follow-on designs. Only one data point per run is needed, per cycle through each of the separate members of the family of that larger orthogonal fractional factorial design set. After suspected active factors are narrowed down, the data points provided by all the screening runs are then used to develop the "master" response plot. In that sense, multiple data points emerge and are all used to form the final big picture of what is controlling the response, even though during each run, only one data point needs to be gathered.

If you already know the active factors and are in the process of refining your knowledge, the number of repeated runs at any given factor combination depends on how much variability you expect to get at each run. If the variability is high for some reason, more runs will provide more degrees of freedom, hence making it easier to find a detectable difference if there is one to be found. The catch is that even though the difference is significant, it may not be great enough to warrant change in practice. If the detectable differences are large in the first place (and therefore likely to be more material in reality) then they will be more likely to rise above natural variability in the first place, and be picked up by a smaller number of replicates.

I think Don Wheeler suggests that in most cases it should not be necessary to have more than 4 or 5 replicates for any given factor combination, and in many cases it will be possible to find everything you need with one replicate. His opinion is that nothing is more powerful than the repeated confirmation you receive once you put your best combinations into action, and see what they do when performed over and over again.Personally, if circumstances permit, I think you can run one cycle through the chosen design. Analyze the results at that point. If the results are not clear for some reason, run it again and re-analyze the results using the two runs and two data points at each run. Repeat until more certainty emerges. Of course, this will not always be possible, and you may have to collect all "replicates" during the same setup.

Combined with the comments you receive from others, I hope this helps!

Regards,

Paul Selden

Topic /Ref : S?N Ratio Analysis (Ref : DOE-DG37-010116)	
Question	Answer / Discussion

I want to ask you a question ,which I could not solve after refering many books.
CAN I USE S/N RATIO ANALYSIS WITHOUT CONSIDERING THE OUTER ARRAY FOR THE NOISE FACTORS?
BECAUSE even IF there are no outer noise factors (or could not be included in the study as they cannot be changed as per particular array due to some reasons) , But the inner noise factors like machine aging, inherent factors, shift in control will always there when i take out few jobs on the same setup(in the same treatment).
on response of these repetitions/replications can i apply s/n ratio method for analysis.
THIS PROBLEM IS RELATED TO MY PROJECT ASSIGNMENT WHICH I AM DOING IN THE A LEADING GEAR MANUFACTURING COMPANY IN INDIA.
Please help me out, sir.
yours sincerely,

- Vikrant

S/N analysis can be performed any time there are multiple sample results in each trial condition regardless of the presence of outer array.

Whether an outer array is incorporated in the experiment or not, the effect of noise factors is always present in the results. Having multiple samples tested in the same trial condition under random noise, the results contain the effect of the noise. Use of the S/N analysis helps identify the optimum condition and the factor behavior that are more representatives in the real life. When an outer array is used, additional information in terms of the effect of individual noise factors can also be identified.

Perhaps you have already discovered that Qualitek-4 allows you to perform S/N analysis even when you do not have an outer array. You can check this fact by opening and analyzing experiment files PISTON.Q4W and PISTON1.Q4W.

Hope this gives you enough leads for further investigation.

- RKR, 01-0116

Topic /Ref : Title or Key Words (Ref : DOE-DG38-010209)	
Question	Answer / Discussion
I have a problem about Taguchi DOE. Let's us say that we have one 2 level factor, three 3 level factor that is L-9. Can Taguchi give the optimum value according to both levels in the 2 level factor seperately. Otherwise Do we have to make 2 DOE for first level of two levels and second level. Thank you, -Dr. Sinan HINISLIOGLU	*You do not need to run two separate experiments in this case.* *When you have multiple factors, not all of which are at the same level, you should want to design a single experiment to study their effects. In your situation (One 2-level factor and three 3-level factors), an L-9 with four 3-level columns can be conveniently used. To modify the array and accommodate the 2-level factor, you need to downgrade one (any column) of the four levels first. The process of downgrading is also known as DUMMY TREATMENT. To downgrade, you simply change the level# 3 in the column to #1 (for description of the experiments). This, of course, destroys the orthogonality of the experiment design, but is a practical way to carry out the design. To complete the experiment design, assign the 2-levl factor to this modified column and the three 3-level factors to the remaining three 3-level columns.* *After you carry out the experiment, when you are analyzing the results (calculating average effects etc.), be sure to include 6 results for one level of the 2-level factor and 3 for the other.* - RKR, 01-0209

Topic /Ref : DOE for Special Validation Testing (Ref : DOE-DG39-010219)	
Question	Answer / Discussion
I am testing power supplies and things are getting out of hand. The engineers are prescribing running through a complete set of binary combinations of two levels for each factor; minimum and maximum input voltage and output current for load current #1, load current #2, load current #3, load current #4, load current #5, load current #6, load current #7...etc. Even with automated testing, 2 to the 5, 6, 7 8th combinations can take a very long time... These tables are further complicated by additional rules, such as "V1(load current #1) + V3(load current #3) < X", where X is a constant that's less than V1(load #1max) + V3(load #3max). In English, you cant fully load both outputs to specified capacity simultaneously. What this does is further expand the table, because two entries are needed to be able to set each factor individually to the max current level.	*An orthogonal array layout would certainly be a smarter way to test. If you are not looking toward testing each and every possible combination, then the DOE approach using an appropriate array will work for you provided the factor influences (effects of factors between the two levels) are close to being linear.* *The DOE could give you best and worst performing configuration along with knowledge of the individual factor influence. You could either test with factor that influence performance or with factors comprising of the application*

There is a belief that the quality of the performance qualification will suffer unless _each_ combination of operating paramaters is explicitly looked at. I have suggested testing at random values for each factor and extrapolating / using statistical analysis to arrive at indications of a problem. The engineers want hard failures; i.e. a specified value was exceeded or not, rather than an indication that it "very probably will be". The problem is that the tables are getting so hard to construct (because there is yet another factor which perturbes the values on an output by output basis, to avoid violating one of the combination rules, which implies individual tables must be generated for each output to be tested) that the advantage of using automated testing itself has come into question because of the time involved to correctly build all the necessary tables.

This, being my career here, is a bit upsetting...I've known of DOE for some time and analysis of experiments, to isolate significant factors contributing to a response and use this information to effect a better design. However, this is qualification of an existing product where the interest is primarily "does it meet the specified criteria or not" even superceding "how much did it miss by?" Is there a way to create a thorough qualification examination test using tables designed for factorial experiments - which I can also be correct in claiming they are every bit as effective as testing every possible combination of 2 level factors?

-Joe Jasniewski

Automated Power Systems Test Engineer

Entry/Mid-Range Server Division, Intel Corporation

environment. As long as the trend of influence can be assumed to be linear (or close to linear), the best and the worst conditions would represent the two extreme conditions. All other condition (combination of factor levels) are expected to fall between these two. Should you need to test some critical/specific condition, you can do so now, separately.

- RKR, 01-0219

Topic /Ref : Column Downgrading (Ref : DOE-DG40-010319)

Question	Answer / Discussion
I have **one two level** factor, **four 4 level** factor. I think L-16 is suitable. But which levels and how will I downgrade to 2 level. Especially How can I create the convenient orthogonal array for this study in the Qualitek-4. Best Regards, -Dr. Sinan HINISLIOGLU	*You have two options in Qualitek-4 to design the experiment with One 2-level factor and Four 4-level factors.* *Use manual design. Select L-16 (modified, which is M-16 in QT4) array. Then assign the two level factor to any of the five columns. Reduce the column levels to 1 & 2 by replacing all 4 with 2 and all 3 with 1.* *You may also select the AUTOMATIC design option and let Qualitek-4 design this experiment for you. It may start with the regular L-16, but the design will be valid and similar.* *(You may also consult www.rkroy.com/wp-tip.html for more explanation and other design situations)* - RKR, 01-0319

Topic /Ref : Interaction between 3-level factors (Ref : DOE-DG41-010320)

Question	Answer / Discussion
In my project, I have problem about DOE . I have three factors and two of them have three levels and the other one has two levels thus I must select L 18 orthogonal array but there is problem because I didn't find any interactions graph between two factors .for example factors are : A , B, C and their levels are : (A1,A2,A3) ,(B1,B2,B3) , (C1,C2) respectively there are interactions between A and C , B and C , A and B . Could you please tell me how can I set orthogonal array? or what kind of orthogonal array Can I use? Please help me. - zahra akbari	*Study of interaction between two 3-level factors is quite complex. You must be build a good background about the design and analysis technique before attempting this. Taguchi 3-level Orthogonal arrays such as L-9 , L-18 etc. can be used to set up interaction studies. The columns you need to reserve are indicated by the Triangular Table for the 3-level arrays.* *Please be aware that Qualitek-4 software and my text books do not explain or support design and analysis of interaction between factors that are other than at two levels.* - RKR, 01-0320

Topic /Ref : Estimating Optimum Performance (Ref : DOE-DG42-0410)

Question	Answer / Discussion
What is the formula for prediction of result at optimum condition for the nominal the best? I could not find it in the books. Thank you for your time and consideration. Sincerely yours, - Younes Leysi	*There is no separate expression for estimating optimum performance in case of NOMINAL quality characteristic. This is because, in standard analysis, the results (single or multiple per trial condition) are always reduced to DEVIATION by subtraction of the target value from the results and taking the absolute value. Once the results are reduced to absolute deviations, SMALLER IS BETTER quality characteristics will apply for analysis. As you already are aware, the expression for estimating the performance at the optimum condition (Yopt) is the same for both BIGGER and SMALLER quality characteristics.* *There is however, one possible problem with reducing the results to absolute deviations and performing standard analysis. The trend of influence (Main Effect) may not always support the selection of the optimum level. This matter is little too complex to describe in words alone.* *A better practice will be to analyze results for NOMINAL quality characteristic by using signal-to-noise-ration (S/N) of the results, which should be your choice as long as you have more than one sample results in each trial condition. Analyzing results by S/N and the corresponding selection of the optimum levels and performance will always be more reproducible (likely to be tested and confirmed/verified)* - RKR, 00-0000

Topic /Ref : Orthogonal Array for Mixed-Level Factors (Ref : DOE-DG43-010418)

Question	Answer / Discussion
My friend could like me to make a DOE according to Taguchi Method. There are 4 factors. Three of them have 4 level and one of them has 2 levels. Can you recommend an orthogonal array for this study. Thank you for your help. -Dr. Sinan “Sinan "Hýnýslýoðlu"	*A modified L-16 array will be suitable for this experiment. Suppose that the THREE 4-level factors are called A, B & C, and the ONE 2-level factor is called D. You have the option to, either start with an L-16 (2^15) and modify this array, or start with the modified L-16 (4^5). Your job is slightly easier when you start with a modified L-16, which has FIVE 4-level columns. In this case you can assign factors A, B & C to columns 2, 3 & 4 respectively. You will need to dummytreat (downgrade) column1 to reduce its levels from 4 to 2. To do this, replace all 3’s by 1’s, and all 4’s by 2’s in the column. After downgrading, assign factor D to this column (column 1). Finally, you will need to discard column 5 (set it to zero or as UNUSED in Qualitek-4 software.* *I just noticed that Qualitek-4 is unable to produce this design, even though it does create design for FOUR 4-level factors and ONE 2-level factor. The reason is very simple; it was not programmed to do*

it. You can indeed fool the program by taking one extra 4-level factor, then later discarding it.

- RKR, 01-0418

Topic /Ref : DOE application in Banking Service (DOE-DG44)	
Question	Answer / Discussion
We are writing to you after visiting your magnificent website..we are very delighted of what we learned from it. We are **students at the University of Jordan**, Industrial Engineering Dept.. We are in our fourth year and we are seeking help in understanding how performance measures are quantified and how parameters are set for a banking service. And we are mostly interested in how Taguchi Technique can be applied inthe **banking service industry for process improvement**, this is the theme of our graduation project. We will be very thankful for any kind of help you might provide. - Dina, Anan and Faten	DOE/Taguchi technique can be applied anywhere you have a need to study multiple factors (variables, input, parameters, etc.). Perhaps the factors in your banking services are, *type of business, amount of loan, duration of loan, interest rate, other expenses, application processing time*, etc. To evaluate the output/results, you must select some measurable quantity like*, return on investment (ROI), customer satisfaction, % profit,* etc. I suppose, instead of common approach where you will setup experiments and then run them, you will try to search for conditions that matches your layout among available case histories. Your challenge will be to define the factors and the objective criteria. I assume the matter of designing the experiment and analyzing the results are known to you by now. DOE could be highly effective for you if you happen to have an *analytical simulation* of the banking process under study. In that case you will be able to take the liberty with defining the factors used in the *analytical simulation* carefully to make your model produce the desired objectives. The simulation model, of course, allows you to run the DOE trial conditions prescribed by the design. You must then analyze the output of the simulation using the principles of DOE result analysis. - RKR, 01-0424
	I am a member of the DOE- Discussion Group and I would like to make some comments on your question. First of all, you need to understand that application of DOE in service processes is uncommon. This is simply because there are so many factors within the service processes are uncontrollable (e.g.: emotional conditions of the service provider at the counter, attitude of the service provider, human behavioural) but at the same time they have significant impact on the service performance. Moreover, data collection in a service environment takes a much longer time compared to a manufacturing setting. However, it is very much possible to apply DOE in a banking industry to improve the service process performance. You need to develop a model that reflects your service process through simulation (as suggested by Dr Roy). Once you have this in place, it is much easier to run the experiment where you can vary all the parameters at their

level settings. Remember, WHAT YOU MEASURE IS WHAT YOU GET !!!!!
Measurement of critical service attributes is very crucial in your case. It would be better to identify what to measure through a thorough brainstorming session with people in the bank. Once you identify the key parameters through DOE, you can then optimise them for greater service performance.
I am quite happy to help you out with this project as I am very keen to know the results of your study. So please keep in touch and we can discuss the various stages of your project. I would also want to tell you that people have successfully used Gap Model developed by Zeithaml, Parasuraman and Berry for evaluating service quality in service processes. You may have to consider this as an option. Probably an integrated approach (DOE + Gap Model) would be very useful in this study.
Good luck and please do keep in touch.
Regards

Jiju Antony

Topic /Ref : DOE application in Mixture Designs (DOE-DG45)	
Question	Answer / Discussion
How are you? It's been over a month since you were here at PCI teaching the Taguchi Approach to DOE, and I have a question regarding the application of this to a mixture design. Since the relative amount of any material in a solution is constrained between 0 and 100%, and the sum total of all components must equal 100%, how is this best handled in a DOE? How would you recommend that I proceed with setting up this type of DOE? -Clair Reynolds	*Your case presents an interesting challenge. To use the standard array and following the design steps discussed in the class, you have to carefully select the factors and their levels for the study.* *Suppose that you have seven 2-level factors (A, B, …. G). Since (A + B + …. G) must always equal 100%, you need to study only about half of the factors at one time. And this would be possible only if the other half can be allowed to be set to values that complements the factors being studied.* *Consider that factors A, B, C, and D are chosen for study. The levels of these factors must be set such that the differences in the level values equals the known values (assumed fixed) allowable level differences of the factors not studied (E, F, and G, factors with least expected influence).* *[(A2-A1) + (B2-B1) + (C2-C1) + (D2-D1)] = [(E2-E1) + (F2-F1) + (G2-G1)]* *Since this a single equation with multiple variable, you cannot solve for the unknowns directly. You will have to establish the levels of A1, A2, B1, B2, etc. by trial and error.*

Hope this gets you started.

- RKR, 01-0421

Topic /Ref : Overall Evaluation Criterion (OEC) in Qualitek-4 (DOE-DG46)	
Question	Answer / Discussion
In Overall evaluation criteria definition, after completing the first two steps, in the third step there is a statement which is " Click OK to accept OEC (White area) as results of experiments and return to Configuration/Main screen". But there is (1) **no OK button** in the overall evaluation criteria screen. In addition, there is another statement at the bottom of the tips for preperation of OEC which is Note: Depending on the individual QC and their relative weighting, Qualitek-4 assigns the QC for OEC. (2) For criteria with 30% or more Rel. Weighting, **Bigger QC** is assigned for the OEC. I do not understand this statement. Please can you explain it and (3) In order to fill the white area (QC of the overall evaluation criterion) what do I have to do. Sinan "Hýnýslýoðlu"	*(1) The **OK** button in Tips from OEC screen of Qualitek-4 has been replaced by **RETURN** button. Apparently, the reference to this button in the explanation under Tips has not been updated. (OEC can be reviewed in Qualitek-4 by opening file: POUND.Q4W and selecting Evaluation Criteria from the EDIT menu in the Experiment Configuration screen). Thank you for bringing this discrepancy to my attention.* *(2) The second question you raised requires detailed explanation of the quality characteristics involving multiple criteria of evaluation. I will give you a brief explanation and ask that you read literature provided in the reference below.* *The multiple criteria of evaluations, which are combined to form the OEC, often will have their individual quality characteristics (QC) that are different from each other. Of course, before they are combined to form a single criterion, all individual QC's are converted in to one kind, bigger or smaller QC. When you have a mixed situation, that is, a number of criteria are of smaller, a few are nominal (reduced to smaller QC when deviations are considered), and others are bigger, what are you to do? In this situation, there becomes a need to make a choice about what to make of the QC for the OEC. In Qualitek-4, OEC is formulated to have bigger QC as long as the criteria with bigger QC total over 30% relative weight.* *No matter how many criteria you include in your OEC, it is always a good idea to test your OEC number to see if it is consistent with your understanding of the QC for the OEC. To test bigger QC for OEC, if you put all worst value for a sample, the OEC value will be 0. Conversely, when the sample evaluations are set to best value, the OEC value will be 100.* *If you have the new text: **16 Steps to Product and Process Improvement**, you will benefit by reviewing examples 13.1 and 13.2. Also, review discussion under Rationale for the OEC Formulation at bottom of **page 54.** If you do not have access to the text, then visit and explore two sites listed under reference 2 & 3 below.* *(3) The white area in the OEC screen (Qualitek-4, screen for entry of multiple criteria of evaluations/results) is for display purposes only. When you first describe criteria in the yellow area and then enter all sample evaluations in the green area, the OEC will be displayed in the white area automatically.* - RKR, 01-0522

Topic /Ref : Taguchi Experiment with Attribute Data (DOE-DG47)	
Question	Answer / Discussion
How can the Taguchi software be used for DOE designs, in which the output is attribute (e.g., pass/fail) data? For example, if I have a scrap issue for a visual defect at a 1 % failure rate and I want to be able to detect that I decreased the problem to less than 0.01 %? I know how to handle this with the traditional full and fractional factorial experiments, but wanted some guidance from you on using the Nutek software for this problem. I will provide a hypothetical number of control factors as 8 with two levels and no interactions. Respectfully, Clarice Fasano	For **attribute data,** Dr. Taguchi had a special treatment of results called **accumulation analysis**. The Window version of Qualitek-4 does not include this capability, as it is quite involved and require additional background study. A common practice to handle attribute data of all kinds is to first find a way to **QUANTIFY** the results (say 0 for FAIL and 1.0 for PASS, etc.). Once the results are evaluated in terms of numbers, analysis could be performed as done for any other results. You would, however, confront **two challenges**. First, when you are dealing with small failure numbers like 1% or less, it will require you to evaluate the results from a larger sample (# of failure among 1000 parts). Of course, you will not need to deal with such larger samples if the expected failure numbers are much higher (10%, 15%, etc.). If somehow you can overcome this, the second thing you need to worry about is the fact that all contribution from factor adjustment should not, practically, add over 100% (when results are expressed as, say % failure). This anomaly can be avoided by transforming the results into a scale from – infinity to + infinity (α). This transformation is known as OMEGA transformation and can be easily done in Qualitek4 software (Edit-Result-Transform). For additional discussion about the attribute data and the recommended practice, refer to text **Design of Experiments Using the Taguchi Approach: 16 Steps to Product and Process Improvement** by Ranjit K. Roy. Hardcover (January 2001, John Wiley & Sons). This book has a CD-ROM containing over 150 example experiments and exercise solutions. Read page 68 under heading **Result**. - RKR, 01-0621

Topic /Ref : Implementation of Design of Experiments in an Organization (DOE-DG48)	
Question	Answer / Discussion

I have had your name, thanks to Willie Lottering. I m actually a student in the Cranfield University (england) doing a MSc in Quality Management. This MSc forecasts doing a thesis for 4 months, in different subjects dealing with Quality. As i m interested in the methods called DOE, i ve chosen a thesis with this subject. My role here is to give some piece of advice for implementing DOE in the different labs of my university. Unfortunately, I've seen a lot of books concerning Design of Experiments, but none of these deal with the implementation in itself, and the methodology used to implement it. I've hence looked on your website and saw that you were an expert in a such domain.

Could you please give me some references to help me, or just anything that you may think would be useful for my research..

Thank you kindly in advance for your reply
Best Regards,

-"Christophe "
MSC in Quality Management, Universite de Technologie de Compiegne, France

You have raised an interesting question for which I would also be interested in the answer. Your observation about reference textbooks is also correct. I know of no texts that deal with implementation of the DOE technique specifically. Perhaps the reason for that is that there is no unique strategy for implementation. In my observation, the successful organizations world wide have used different approaches

Suppose that you are the head of an organization or otherwise responsible upper management. You have learned the technique and are convinced your activity would benefit by applying such technique, how should you go about it?

*Here are some of my **thoughts**. I would be very much interested in the **experience and ideas of others who read this discussions**. There are a number of academic professionals in our group. Perhaps some of them will be able to offer some ideas for you on how to go about introducing to research laboratories.*

Good knowledge/understanding of the technique by the management personnel is essential. Since, if they know it well then only they can "ask the right questions".
All personnel involved should be exposed to an overview session.
All potential users should have a detailed course that teaches them how to apply. Not all who attend such course will remember how to apply or practice on a regular basis. But then, not all are needed to provide the technical knowledge in application. Only one individual in a TEAM (perhaps the facilitator of the planning session) needs to maintain the knowledge of the technique.
Management should provide the needed training and ask (from the engineering activities) that all DESIGNS and PROCESSES be optimized.

*Hopefully, these thoughts will be of help. By the way, you could also **talk to some of your local organization** and find out how they went about implementing some other techniques, say like Statistical Process Control (SPC) in the production environment.*

- RKR, 01-0627

Topic /Ref : Accomplishing DOE Project Applications (DOE-DG49)	
Question	Answer / Discussion

My name is Andres Felipe Maya and I am working for an appliance manufacturer company located in Medellin, Colombia (South America), its name is Industrias HACEB S.A. and is 60 years old. HACEB S.A. is the most important company in the appliance colombian market. I work in the R&D department and we are currently investigating about the feasibility of implement Robust Design in our manufacturing and design process. I would like to know if you can help us in our project research and, if this is possible, how could you help us?, can you send us some information about the Robust Design?.

Please, let me know how good would be your help.
Best Regards,

ANDRES FELIPE MAYA POSADA

For the sake of discussion, let's assume that you have identified DOE as the technique to accomplish a project, be it solving production problem or design optimization. Your goal is to complete the application. How should you go about it?

The question asked, although, of private nature, deserves a general discussion. I often get questions of this type. If you were an expert, mentor or otherwise responsible individual within an organization, you would do well by weighing the appropriateness of different strategies and stick to one for effectiveness.

Basically there are two approaches:

***Learn and Apply Yourself**– In this approach you would learn how to apply the technique and yourself and lead/help your project with the application process (plan & design experiments, analyze results, confirm findings, etc). To successfully apply the technique to your project, you need only one or more members to obtain and retain application expertise. However, you will benefit by having other members of the team and other people in the organization be exposed to the details of the technique. When more people around your projects are aware of the technique, you will spend less time selling the goodness of the idea than applying it to the project.*

Here again you have three ways to go.

Procure one or more available books to learn at your own pace (negligible cost, but time consuming)

Attend a public seminar alone or with other team members. Look for seminars that have emphasis on application and make you ready for project accomplishment. (inexpensive and quick)

Host seminar/workshop at your own facility and attend with team members and other key personnel. Your intention will be to gain expertise (one or more from all attendees) and apply the technique immediately to the project. Generally, you benefit much more by hosting a seminar at your facility and attend with all team members. A well run workshop ought to make you ready for immediate application. You still have to guide the project team toward completion after the instructor leaves. (costly, but readied for immediate application)

***Apply with Hired Help (consultant)** – I this case you will be looking for some one who can help you accomplish your project goals all the way from start to finish. From the project point of view, this is the most effective way to go, but you do not learn much about the principles behind. You will need help again for your next project. However, if accomplishing your project goal is of primary importance, this is the way to go. Just make sure that your consultant can help you with the following phases of your project. (generally as expensive as onsite training, but more certain and fast)*

Phase-1 Facilitate Experiment Planning

Work with your project team by facilitating the experiment planning session, and help the project team objectively identify the performance criteria and the relevant factors to be included in the study.

Process Research Analyst

, Industrias HACEB S.A.

Autopista Sur #1-21,

Medellin, Colombia

Phase-2 Layout Experiments and Prescribe Data Collection Scheme

Describe the trial conditions based on the factors identified. These descriptions serve as the work order for each separate experimental condition. Prepare and prescribe the data collection scheme.

Phase-3 Analyze Results and Recommend Solutions

Analyze the results of the experiments and derive information such as: (1) Factor Influence (Main effect), (2) Relative influence of the factors to the variation of results, (3) Optimum condition, and (4) Expected performance at the optimum condition. AT conclusion of the analysis, a brief report containing the solution-design and recommendations should be prepared.

- RKR, 01-0721

Dr.Roy showed a way, how to apply DOE in your company. I would like to add some comments.

I learnt and implemented DOE (as a consultant) in many companies in Czech Republic.

I have this experience:

The best way, how to start, is 4-day application on-site seminar. Participants - the first members of experimental team, say 8-15 people from various departments (e.g. R&D, quality, production, marketing, etc.)

Then start with simple experiment. External consultant is required. The consultant will check mainly planning phase, but design, analysis and conclusions from analysis as well. Such experiment should be a "sample" for following experiments. Note: At this time, considerations about DOE software are needed.

Then apply DOE to more difficult experiments. It is desirable to work with consultant - chose 2 people, who will work together with consultant. After several months the 2 people will become DOE specialists and will know most of common experimental solving. How is it possible to help directly?

It is possible to ensure all services above. How is it possible to be of help via internet?

a) teach DOE/robust design - not possible b) consulting - planning experiment - not possible

- designing experiment - possible to do or check analysis of experiment - possible to do or check

c) software - possible, try to download L-8 demo Qualitek-4,

www.rkroy.com or www.pqm.cz

d) information about robust design/DOE - it is quite long and wide

topic to write all information. Try to read fundamental information in

www.rkroy.com or www.pqm.cz

Best regards,

-Pavel Blecharz, Ph.D.

Topic /Ref : Taguchi Approach Vs. Full Factorial (DOE-DG50)

Question	Answer / Discussion
I'm a student of Manufacturing Engg at Madras institute of technology-Anna university, Chennai, India. .I'm doing a project on eyestrain measurement. The measurement procedure involves a preliminary step of designing the experiment. The design is going to be a full factorial one. How would Taguchi method help my cause. Yours sincerely N.Manikandan "manik kandan"	Often FULL FACTORIAL experiments in which you test all possible combination of the factor levels is not needed as it is possible to arrive at the solution by running a fraction of it. Taguchi orthogonal arrays are smallest fractional factorial for the situation. When the number of factors is large, testing full factorial experiments become time consuming and expensive. Experiments designed for the same study using an orthogonal array is likely to produce the same determination. In most cases, running the additional tests to cover all possible combination is not worth the cost and time. Besides, when you run all possible combinations, you will face a greater challenge to make use of the statistical data produced by the additional tests. Here are some reasons why you should prefer the Taguchi Approach: 1. Smaller number of experiments 2. Easier to design and perform experiments with mixed level (2-level, 3-level, 4-level, etc) factor 3. Use of S/N (Signal -to-Noise-Ration) for analysis of results, which allows determination of the optimum design based on variability and mean together. 4. Easy to study and incorporate design modification based on interactions between two 2-level factors. 5. Allows you to perform standardized method for analysis of results 6. Allows you option to pursue ROBUST DESIGN by treating the NOISE FACTORS formally using the OUTER ARRAY designs. 7. For production and manufacturing purposes, you will be able to translate the cost implications using the Taguchi loss function. 8. Etc. - RKR, 01-0617

Topic /Ref : Books - A Primer Vs. 16 Steps…. (DOE-DG51, July 18, 2001)	
Question	Answer / Discussion
I would like to know is there any difference between *A Primer on Taguchi method* book edited in 1990 and its recent edition. Also please send and email and let me know the recent edition specification. Sincerly yours, Talat Ghomashchi lecturer of chemical engineering, department,technical faculty Tehran university	My latest book is ***Design of Experiments Using the Taguchi Approach : 16 Steps to Product and Process Improvement.*** This book is totally new (January 2001) and different in many ways from the last one. This text is more practical. It contains many application case studies and contain a CD-ROM with Qualitek-4 DEMO program and solutions to all examples and exercises in the book. Readers can learn the application principles while reviewing the examples and calculations on the computer screen. This text will be more suited to people wishing to learn the technique in their own time at their own pace. (You will get more out of this book when you study it along with a **computer**) My earlier book, ***A PRIMER ON THE TAGUCHI METHOD*** *was published in 1990. It* is a practical guide, which introduces you to the basic concepts, techniques, and applications of the Taguchi approach, in a clear simple, and essentially non-mathematical presentation. If you want to muster the theory behind the Taguchi experimental designs, you will benefit by reading this book. Many university professors teaching courses that include computer training prefer the ***16 Steps***.. To review the content of the above texts, follow the link below. (If you already have read the ***16 Steps***…., please feel free to share your comments so that others may benefit.) Reference: Books on Taguchi approach by R. Roy and other authors: www.nutek-u.com/wp-txt.html - RKR, 01-0718

Topic /Ref : **Multiple Optima Systems** (DOE-DG52, July 19, 2001)

Question	Answer / Discussion

I would like to ask you a question about a special case in which the Taguchi method can be used or not. Sometimes, investigators worry that their systems have multiple optima. Catalyst systems have the potential for multiple optima and polymer systems might also exhibit multiple optima. Although the number of systems having multiple optima is small, but there is no optimization strategy can guarantee that the global or overall optimum has been found. I have not found a technique to use the Taguchi method to solve a problem in this type. Could you please let me now if you have any experience in this way? I am going to think over this special situation. I would be more than happy, if you can directly help me or kindly **send my question to the Discussion Group**. I need a mathematical equation for such a system to check some ideas I have. I hope I can find a new technique to use the Taguchi method for the multiple optima systems.
Thanks in advance for any suggestions and for your time and consideration.

[It is completely different from the multiple criteria, which you have called Overall Evaluation Criteria (OEC) in your book and homepage. I mean that a system has different (local) optimum points, but one of these optimum points is really the best (biggest or smallest).]

Truly yours,

Younes Leysi-Derilou, MS
Consultant and Researcher

I believe using Taguchi you may find main effects of factors giving different levels as defined.
In order to find a global optima, you need to search all feasible solutions using optimization techniques.
If the search space is small and your Taguchi can cover your landscape then you will be ok.
If the search space is too large or complex, you have to look into artificial intelligence approaches such as genetic algorithms.
Good luck

[Garcia, Jose]

Topic /Ref : **S/N Vs. Standard Analysis** (DOE-DG53, August 8, 2001)

Question	Answer / Discussion

This is Janet Savarimuthu, Graduate student at the University of Tulsa, OK - and to be brief - my research is " Optimization of WC Thermal Spray Coatings" and I have incorporated the Taguchi Analysis - So I bought your book -
it was really good with the software which makes one very clear about the concept. Yet i have a few questions - if you dont mind - please answer them when ever you are free:

We made up a function for weight loss of a material, it was an L8 with 2 levels - 5 factors and one interaction, and three replications.

1. You have suggested us to use the S/N analysis for more than one
replications - but i ran both the standard as well as S/N analysis - I found
that the standard analysis was more consistent with the result than the S/N
analysis. At 90% confidence Interval, the S/N had a very wide range but the Standard analysis had a smaller range. Im pretty confused as to choose which method. In that case - then what is the significance of using the S/N analysis?

2. For this case : 5 factors and one interaction, with 3 replications, the total DOF for the S/N analysis is 7 whereas for the S/N analysis, it is 23 even though we are just taking the average of the replications?

3. The software attached to the book, assumes the F(variance ratios) to calculate the confidence Interval to be of constant value . And in the "Design Of Experiments using the Taguchi Approach" page 221, first paragraph-

Your questions require more detail discussions than what can be explained briefly here. I would attempt give you some key points.

1. *S/N is a function of both mean and variability (Std. Dev.). Therefore, any time we have option to calculate variability of data and incorporate it in our analysis, the conclusions derived are more reproducible and statistically valid. It is quite natural that at the lower number of sample data (2, 3,4 etc.), the statistics like average and standard deviations are not as population representative as a larger sample from the population. Even then, S/N analysis for smaller sample will be more reproducible in the long run.*
2. *Degrees of freedom (DOF), by definition, is calculated by subtracting 1 from number of total results. In analysis with S/N, there are only 8 S/N for an L-8 experiments. Thus the DOF is 7. For standard analysis, in ANOVA calculations, all results are included (not just the mean). Since there are 3 results in each trial condition, the DOF = 3x8 – 1 = 23.*
3. *Qualitek-4 software uses an approximate routine to compute the F-ratios. For DF of the error term less than 3, the computation produces number that deviates from the exact solution significantly. This would directly affect the confidence interval (C.I) calculated for the performance at the optimum condition. Should you need more accurate numbers, use the values from F-Table in any standard text on statistics and manually calculate the C.I..*

Yes, the regular version of the software will allow you to design experiments with mixed level factor. Of course, the DEMO version you have with the book will also allow you to design mixed level experiments that uses an L-8 array (One 3 or 4-level factor and up to four 2-level factors)

Thank you for reading the book and for your interest in technical theories behind the applications. Good luck with your research.

- RKR, 01-0808

Just want to add an important point when you deal with S/N analysis, especially when you carry out ANOVA on S/N ratio. As you know, S/N is a single performance measure index combining both mean and variability and

you have
mentioned that,"For values of error DOF smaller than 3, the computation is unreliable as the F-ratio is highly non-linear" - are we supposed to use the F- ratios according to the software - or are there any scientific reasons for that?

The sample we are running is just for practice - we did not work on the original experiment - actually we are planning to get your software. Can we use the software (the paid one) for different levels in the same experiment?
i will really appreciate if you reply to my mail - looking forward to your reply.

Regards

Janet Savarimuthu <janet-savarimuthu@utulsa.edu>

therefore the degrees of freedom is equal to 8 -1 = 7 in your experiment. I don't personally stick with the idea of creating degrees of freedom for error as 3 by pooling effects of lowest sum of squares. I would rather strongly encourage you to use Half Normal Probability Plot advocated by Cuthbert Daniel, a classic statistician. It is very simple to employ in all industrial experiments for factors at 2-levels. A Half Normal plot will tell you which factors need to be pooled and which ones are real factor effects. This is a better and robust way of analysing S/N when you have no degrees of freedom for the error to start with. Should you require further information, please do not hesitate to contact me.
Regards

- Dr Antony

Topic /Ref : **Dynamic Systems** (DOE-DG54, Aug. 9, 2001)

Question	Answer / Discussion
I am interested in using the Taguchi method to find the optimal conditions for a coagulation assay. The input to the assay system will be a drug concentration in patient's plasma and the output of the system is time in second. Depending on the concentration of drug in patient's plasma, the time will increase accordingly (nonlinearly). After reading your book - DOE using the Taguchi approach 2001" I have the following questions: 1. Since there is an input to the system and the output will change accordingly, should I use dynamic system? Is there a way that I can	1. *You have an excellent observation about your system. Indeed, if the output is expected to vary (in direct proportion) with the change of INPUT (which is not a factor), it is likely to be a dynamic system. Such systems are better optimized using dynamic characteristics (DC). As you recognize, dynamic systems are not covered in my book. You will probably need to study this technique before proceeding with applications. You may wish to refer to Dr. Taguchi's System of Experimental Designs or the text by Glenn S. Pace (visit www.rkroy.com/wp-txt.html for a list of references).* *As your preliminary experiments, you should consider designing experiments as static systems where you will keep the input fixed. You can then repeat the same experiments with a different input level. It is quite likely that such experiments will produce the same optimum condition, even though the performance levels are likely to be different.* 2. *Qualitek-4 has full DC capabilities. You can test the DC capabilities with the DEMO software by review the example experiment file DC-AS400.Q4W provided with the program. After loading this file, you should select* ***Dynamic***

use the static system approach?

2. Is your QT4 program (not demo) include the dynamic array? How can I
acquire a full functional copy of the CD-ROM?

3. What method should I use to find the real optimal conditions? The way that I understand the Taguchi method is that the "optimal conditions" are the optimal combinations of the levels of factors that we identify, i.e., we have to input the discrete levels and we will find the optimal combinations of the different factors. When the factors are continuous, how do we find the global optimal level instead of the constrained optimal levels defined by us in the beginning of the experiment?

4. I can see the vast application of the Taguchi method in medicine, especially in laboratory medicine. I need to study the method in depth and apply it in the field of medicine. How much has this technique been applied in the field of medicine?
Thank you in advance for your advice in being a student of the Taguchi method.

-Tak-Shun Choi, M.D.
Clinical Pathologist , Dallas VA Medical Center

***Characteristic** in the **Analysis menu** and proceed with analysis of results.*

You can procure Qualitek-4 software by placing order with us (Fax P.O 248-540-4827) or buy it from www.amazon.com (search for Qualitek-4 in Auction) using your credit card. Visit www.rkroy.roy for details if you need.

3. *It is true, the optimum condition you find from DOE is strictly a combination of the factor levels you defined and included in the study. You could increase your chance of "true" optimum points by studying more levels of the factors (3, or 4 levels). But, when you study more levels of factors you pay penalty in number of experiments. Thus you face two options. You could study all factors at 3 or 4 levels to start with. Or keep all factors at two levels for your initial studies and keep the size of the experiment small. If your choice is the later, you will be able to carry out many small experiments with single factor to identify the behavior of the response with respect to individual factor. Remember that, if the factor behavior is close to being linear, your DOE optimum prevails.*

   ***There just isn't a simple and cost-effective way to determine "true" optimum**. But, should you really care? As long as you CONFIRM your predicted optimum to be with the CONFIDENCE INTERVAL, then for all practical purposes you should claim satisfaction. Perhaps you would come upon similar observation in terms of your ability to study INTERACTIONS and being able to incorporate their effects. Like true optimum, this cannot be done to one's satisfaction. Here again what you want to do is to be close to actual performance. The only way you can know that you are close to actual behavior is by confirming your predition.*

4. *As far as I know, the DOE/Taguchi technique is only recently being applied in medical and other basic research. Some people from drug pharmaceitical manufacturing industry came to my seminar and applied the technique as early late 80's. There is much to be gained by use of this technique for PROCESS OPTIMIZATION and RECIPE FORMULATION regardless of the types of industry. Like you, my feeling is that researchers can potentially benefit a great deal by incorporating simple experiments for ROBUST DESIGNS (include effects of noise factors).*

Hope these comments will be of help to you.

- RKR, 01-0424

Topic /Ref : **Dynamic Systems** (DOE-DG54, Aug. 9, 2001, CONITUED)

Answer/DIscussion	Answer / Discussion
The application of dynamic systems optimisation is not yet common in many manufacturing companies. One of the problems behind this is the identification of SIGNAL FACTOR (S) present in your system or process. SIGNAL FACTORS are those which affect ONLY the mean performance of your system and have no influence whatsoever on system or process variability. For the identification of signal factor in your process or system, you should have a good understanding of your process - which is not the case in many organisations. Taguchi claimed that Optimisation using Dynamic characteristics are far superior to Static characteristics. Apart from Glenn Stuart Peace's book, I would also suggest a book written by Prof. Sung H Park on ' Robust Design and Analysis of Experiments'. In medicine, Robust Design will certainly prove to be useful in many ways. If your study includes qualitative factors with discrete levels, you need to select more than 2 levels. Taguchi's L-18 OA is a useful array for studying up to 7 factors at 3 levels and one factor at 2 levels. You then need to determine the optimal factor settings which provide the best performance. -Dr Antony	1)Static system is a special case of dynamic system. In my experience, so it is better to start with static system. As a result you know process (and DOE problems) much better. Then possibly go further and start with dynamic systems. 2) Qualitek suits to dynamic systems design and analysis very well. 3) You can find optimum exactly quite easy. Example: having 3 level factors, let us talk about factor A. For experiment you chose A1, A2 and A3. A1 is lowest possible value of setting, A3 highest value and A2 is in the middle. Say A2 is optimum for this experiment. But one do not know, if it is real optimum. The follow up experiment is needed. You chose new A1 setting in the middle of former A1 and A2, new A3 in the middle of former A2 and A3.Say, A1 is optimum for this experiment. Another follow-up experiment is needed, with factors setting using the same approach,arround new A1 optimum. Do it as far as results of experiment become the same (no change in results). Then you have absolute optimum. 4) Some reading about medicine is e.g. in the book System of Experimental Design (G.Taguchi). -Pavel Blecharz (Ph.D. Systems Engineering)

Topic /Ref : **Taguchi Approach for Biochemical Reserach** (DOE-DG54, Aug. 13, 2001)	
Question	Answer / Discussion
I am a biologist with some background in mathematics(did my MSc in Physics). I find a lot of use of the Taguchi optimisation procedure in optimisation biochemical and robotic assays that are used for drug discovery. Somehow this method has not been popular to biochemist which is somewhat strange. I would be travelling to US to attend a conference in Baltimore in early Sept. Is it possible to learn about the details of Taguchi methods in one of your 4 day courses. -Santanu Datta PhD Principal Research Scientist & Head of molecular biology, AstraZeneca R&D Bangalore	*Thank you for your interest in applying the Taguchi experimental design technique for your optimization studies. Like you and the feeling expressed by Dr. Choi (se DOE Discussion # DG54), I also feel strongly that there is good application of the design of experiment technique in research of all kinds. I also think the reason why the applications are infrequent is due to the fact that applied statistical science studies are not yet part of the curriculum of mainstream science end engineering in most schools. To my awareness, most universities are teaching DOE/Taguchi technique only through industrial engineering and statistics majors. In my opinion, the applied statistical courses like SPC & DOE should be required courses for all engineering and applied science and technology courses.* *Good luck with your conference in Baltimore. Please feel free to call me when you are in USA and share with me current optimization methods used in your field of research.* *Over the years I have found four days quite adequate to cover more important application methodologies in the Taguchi approach. Most who attended our seminar/workshop tend to agree. This is not to say that you will not require additional studies. I'm pretty confident; however, most motivated attendees will certainly find our* 4-day seminar readying them for immediate applications. - RKR, 01-0424

Topic /Ref : Topic/xx (DOE-DGxx)	
Question	Answer / Discussion
- **xx**	xx - RKR, 01-0424