

## A STUDY OF TECHNIQUE FOR VALUE ENGINEERING FOR CUSTOMERS IN ENGINEERING SERVICES

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### ABSTRACT

This paper describes the VEC technique which has been developed to quickly and accurately comprehend customer needs from the customers point of view to improve services indesign engineering.

### INTRODUCTION

Hitachi Engineering Co.,Ltd is engaged in three major fields: engineering, computer software and electronics. In engineering, we are involved in design engineering for nuclear and fossil fuel power plants and public sector plants, and various types of analysis evaluation services.

Engineering services, such as various types of analysis evaluation services, are knowledge intensive , and a great deal of manpower. It is heavily dependent on the technological and know-how of individuals, so that it is difficult to increase the efficiency of engineering services and comprehend customer needs.

Today, there is a need for a transition from dependence on individual know-how to systematic services.

### BACKGROUND OF THE DEVELOPMENT OF THE TECHNIQUE

The results of structural analysis, thermal and flow analysis or magnetic field analysis calculated by computer for a designated subject based on customer specifications were submitted to the customer. The analysis evaluations in the engineering services were chosen for this study.

Because of the diversification of customer needs in recent years, however, customers are no longer satisfied with submission of the simple report of analysis results only.

Such engineering services are very knowledge intensive, and it is not an overstatement to say that most of the cost is for

labor.

The features of this kind of engineering are:

1. Non-uniform and diversified engineering which is heavily dependent on the technological and know-how levels of individuals.
2. Analysis results or matters to submit are difficult to become a tangible form and have no colors or odors. Because of these features, it is difficult to improve engineering efficiency, and also to understand customer needs accurately . To quickly and accurately comprehend customer needs and improve serviceability we have studied the VECtechnique that has the following features, and developed an evaluation factor analysis system based on that study.

A method which can:

- a. appropriately extract and/or add to service contents (ideas).
- b. flexibly adapt to the various different uses of the items demanded by customers.
- c. put service contents into a form (standardization).
- d. make quantitative judgments as well as those based on senses in regard to values.

### STEPS TO REALIZE THIS TECHNIQUE

This technique, the VEC technique, makes it possible to quickly and accurately understand the customer needs, and to put methods for meeting these needs into specific form.

The steps for realizing this technique are shown in Fig. 1. As this figure shows, we have developed a serviceability evaluation factor analysis system which uses a computer for realizing this technique.

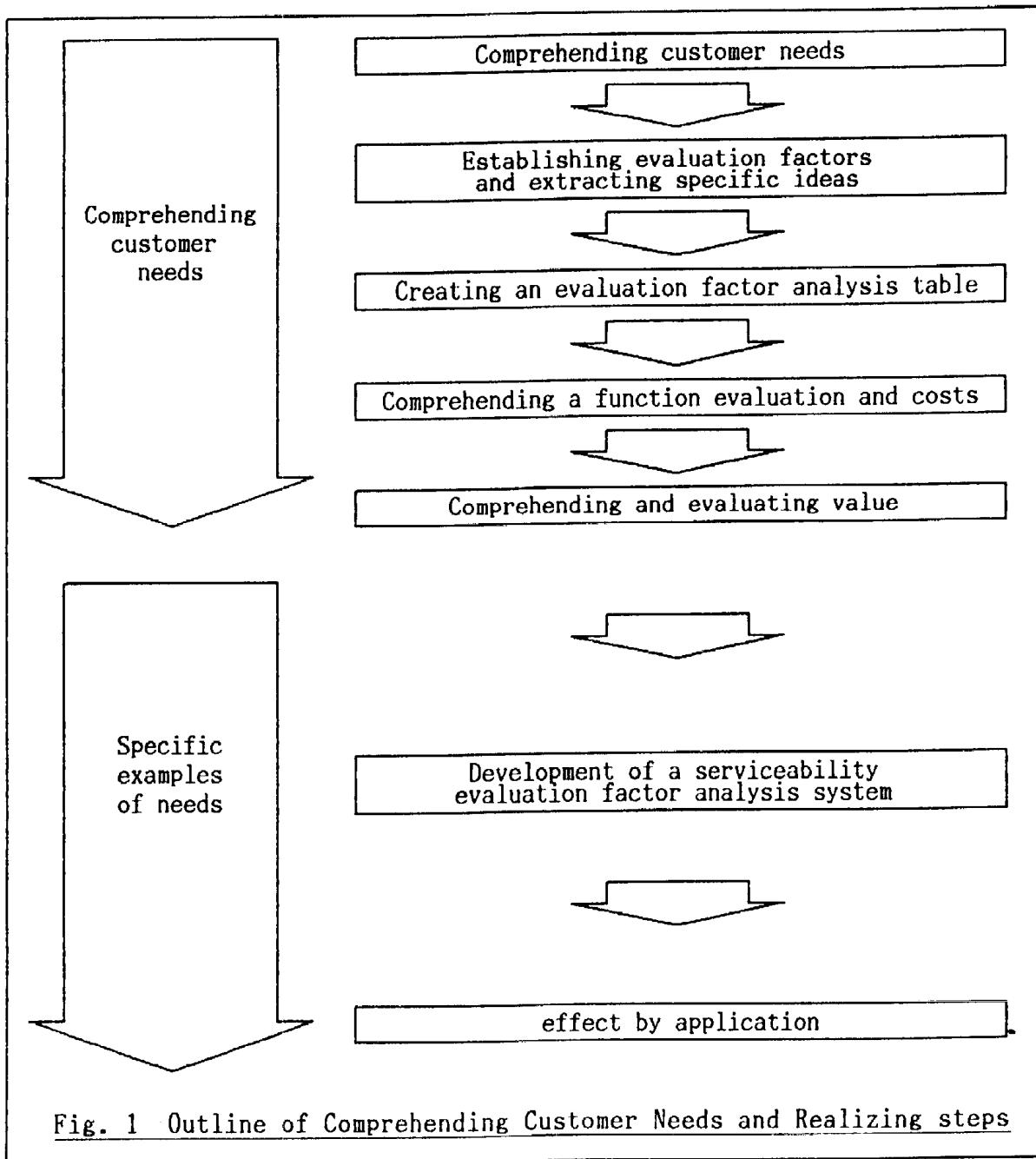


Fig. 1 Outline of Comprehending Customer Needs and Realizing steps

INTRODUCTION OF THE VEC TECHNIQUE  
Establishing Evaluation Factors, Extracting Specific Ideas, and  
Creating Evaluation Factor Analysis Table

Step 1: Evaluation factors for structural analysis evaluation services are established in the following manner:

- (1) Customer productivity - Quickness, ease of operation, adaptability, common use.
- (2) Technological levels - Reliability, ease of maintenance, superiority.
- (3) Impressions - Flexibility, comfort, preferences.

Step 2: Extracting specific ideas.  
 Specific ideas are extracted from conventional services items,

marketing cards, etc., which are based on items demanded by customers and market information.

Step 3: Correlating evaluation factors and ideas. The evaluation factors and ideas established in steps 1 and 2 are matched, weight is attached to each item according to the importance attached by customers to them and the strength of the correlations of the evaluation factors. Weight is attached on a scale of one to five.

Step 4: Creating analysis table of a customer satisfaction evaluation factor. After attaching weight as indicated in step 3, the total evaluation weights for each evaluation factor and each idea are calculated.

EVALUATION OF FUNCTIONS AND COMPREHENSION  
OF COSTS

Step 1: Comprehending the ratio of processes for each engineering step and relative cost of each idea. To comprehend the relative cost of each idea, engineering analysis for labor costs which account for the greater part of costs is executed.

In the engineering analysis the ratio of processes, including final engineering, is calculated. The cost ratio for each engineering step is calculated by attaching weight to the technical levels of each engineering step.

Next, the percentage (additional coefficient) of engineering according to the realization of the ideas is established for each engineering step, and the relative cost for each idea is calculated.

Step 2: Selection of ideas and comprehending costs. The relative costs for each idea calculated in step 1 above are calculated in the following manner. Table 1 shows an example case.

(a) Correlating the evaluation weights and relative cost for each idea (Calculating k).

Evaluation points k per the relative cost for each idea are calculated from the following equation.

$$k = \frac{\text{Evaluation weights}}{\text{Relative cost}}$$

(b) The thinking is that customer satisfaction is higher when k is larger, so that ideas are placed in the order of the size of k. ( $k_1 > k_2 > k_3 \dots > k_i \dots$ )

(c) After putting  $k_1, k_2$ , etc., calculated in (b) in order, the graph showing the correlations between evaluation weights and prices, as shown in Fig. 2, is made.

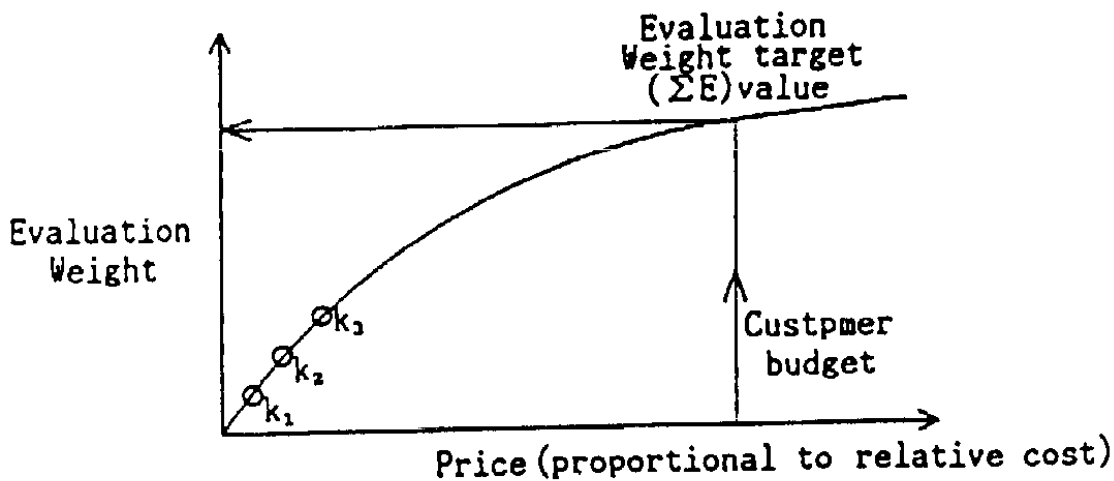


Fig. 2 Relations between Evaluation Weights & Price

COMPREHENSION AND EVALUATION OF VALUE

Step 1: Selection of the three elements of services. Idea items according to the customer's budget were selected and the total of the evaluation points were calculated in step 2 however, these are general evaluations, and the ideas which were selected do not necessarily match the customer's needs.

To match the serviceability evaluation factors with the customer needs, we have conceived the following method in, which serviceability evaluation factors are divided into three

categories which shall hereafter be referred to as the three elements of service.

In the structural analysis evaluation system which is the subject of this study, it is possible to divide serviceability into "faster", "more detail", and "easier to understand" as shown in Fig. 3. Therefore, these have been selected as the three elements of services. Serviceability evaluation factors are allocated to the three elements of services which were selected in the following manner to create Table 1.

Table 1 Analysis table of Evaluation Factor for Structural Analysis Evaluation system

Three elements of services			Faster				Evaluation weights	Supplier		
Evaluation factor			X					Relative cost	k*2	Order of supply
Idea Items *1	Grade of Importance	Quickness	Ease of operation	Adaptability	Common use					
1	Display a flat diagram in three dimensions	A		⊙5			12	0.9	13.3	8
2	Color code the output results	C			○2		6	0.3	20.0	1
3	Output format suitable for the purpose	B	△2	○3		⊙4	9	4.4	2.0	36

Faster . . . Quickness, ease of operation, adaptability, common use.

superiority.

Easier to understand. . . Flexibility, comfort, preferences .

More detail . . . Reliability, ease of maintenance,

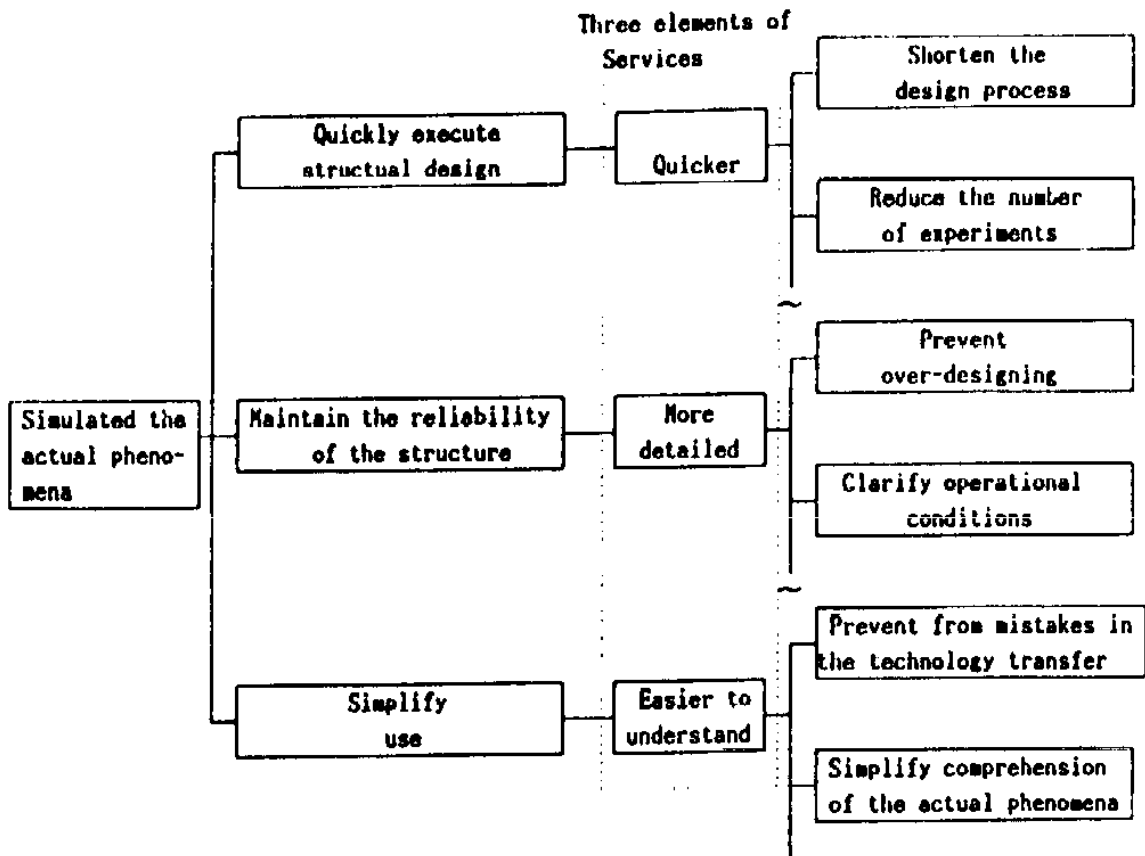


Fig. 3 Outline Diagram of Functions Used in Structural Analysis & Evaluation

Step 2: Attaching weight to the three elements of services. In step 1 above, we divided serviceability evaluation factors into three elements; however, because the degree of expectations (degree of potential customer demand) for each element will differ for each customer, it is necessary to attach weight to each element. The weight must be established by the party supplying services after discussing the situation with the customer, and these are represented by  $P_1$ ,  $P_2$  and  $P_3$ . Here, the following equation is true,

$$P_1 + P_2 + P_3 = 1$$

Step 3: Optimizing customer needs and improving customer satisfaction. The following procedures are executed to optimize customer needs and improve customer satisfaction.

a) From the target value  $\sum W$  of the evaluation weights, calculated from the customer budget in Fig. 2 and the expectations  $P_1$ ,  $P_2$  and  $P_3$  of the three elements of services established in step 2 the evaluation point target values  $P_1 \sum W$ ,  $P_2 \sum W$  and  $P_3 \sum W$  for each element of the three elements of

services are established.

b) To put the customer needs into visible form and make an interactive system with the customer using a computer, the three dimensional cube shown in Fig. 4 is used. The target values  $P_1 \sum W$ ,  $P_2 \sum W$  and  $P_3 \sum W$  of the evaluation weights are located on the X, Y, and Z axes in the cube, and these are established as the E vector. (To make it more convenient for a color display which will be described later, the scales of the three axes are changed, so that the lengths of the three axes are equal.)

If the idea items which meet the customer budget perfectly meet the degree of expectation for the three elements of services, the E vector in the cube will show this, so that the following optimization is not necessary.

c) When the idea items which meet the customer budget are judged ineffective for the customer are deleted, the Q vector shown in Fig. 4 will be created ( $\sum X_0 \sum Y_0 \sum Z_0$ ). In general, this will differ from the E vector, so that the following optimization is necessary.

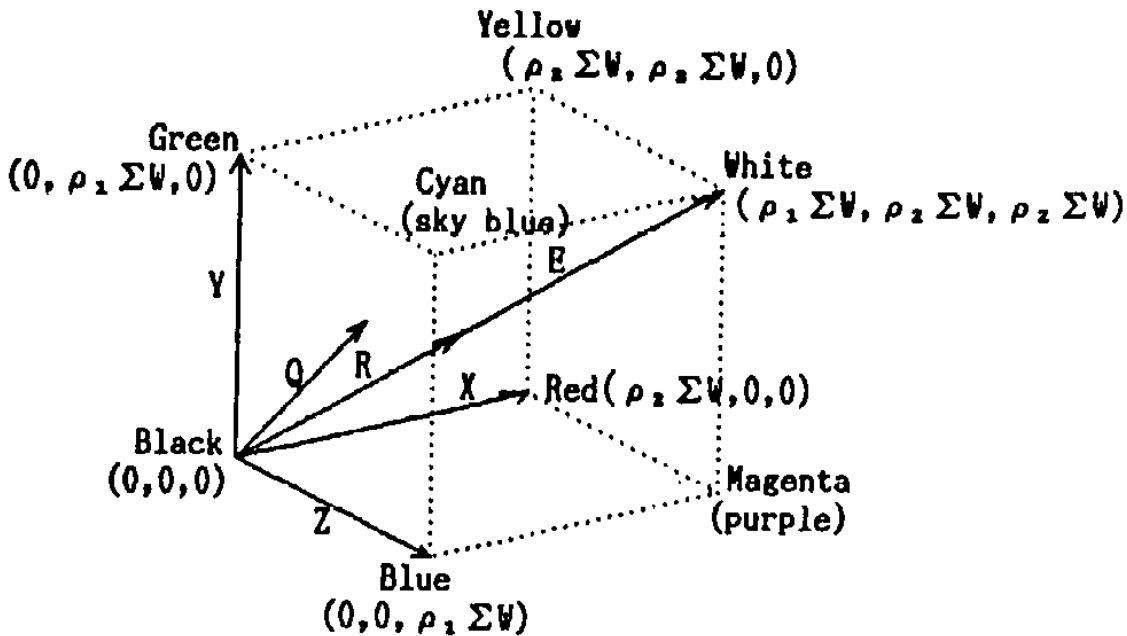


Fig. 4 Three Dimensional Cubic Display Made Up of Three Axes (X, Y, & Z) with Different Scales

d) Optimizing customer needs:

The points indicated on the Q vector do not meet the expectations for the three elements of services, so that the Q vector must be rotated into the E vector by adjusting the idea items to optimize customer needs. The Q vector which has been rotated so that it overlaps with the E vector is referred to the R vector. The R vector elements X, Y, and Z become  $\sum X_2 \sum Y_2 \sum Z_2$ .

e) Improving customer satisfaction

The customer needs were somewhat optimized through the operation in e) however, it is desirable to meet the evaluation point target values ( $P_1 \sum W$ ,  $P_2 \sum W$ , and  $P_3 \sum W$ ) on the E vector. To achieve this, ideas for the difference between the E vector and R vector, i.e., the  $P_1 \sum W - \sum X_2$ ,  $P_2 \sum W - \sum Y_2$ , and  $P_3 \sum W - \sum Z_2$  portions of the three elements (X, Y and Z), must be extracted through discussion with the customer, so that the customer satisfaction can be improved.

f) Evaluation of customer satisfaction Customer satisfaction is determined by evaluating the degree of improvement of service contents after executing a) through e) This evaluation is made by

the following equation.

Improvement in customer satisfaction =

**Total eval. wts. of serv. contents after implemnt.**  
**Total eval. wts. of serv. contents, currently thought ideal**

(Length of the B vector in Fig. 4)  
 (Length of the R vector in Fig. 4)

DEVELOPMENT OF THE SERVICEABILITY EVALUATION FACTOR ANALYSIS SYSTEM

To achieve the optimization of customer needs and improve customer satisfaction as described, the following are believed to be necessary.

(b) For example, if, from among the X, Y, and Z axes, the intensity of the X axis (red) is higher than that of the other colors, the vector in the cube in Fig. 4 is biased towards the X axis, in this case the Q vector. If the colors of the X, Y and Z axes have the same intensity, the vector in the cube in Fig. 4 is the E vector or R vector. If it is the E vector ( $P_1\sum W, P_2\sum W, P_3\sum W$ ) then it is displayed in white. If it is the R vector ( $\sum X_1, \sum Y_1, \sum Z_1$ ), then it is displayed in grey. If the length of the R vector is 0, then it will be displayed in black. Fig. 5 shows an example of this display.

- (i) Quick extraction, addition, and recording of ideas through an interactive format with the customer.
- (ii) The results of (i) must be put into visual form, so that immediate judgment is possible.

To realize (i) and (ii), we used computer display and database technology to develop a serviceability evaluation factor analysis system. The following is the configuration of this system.

- (a) From among the different computer display technologies, RGB display technology which are the most basic and general was used to display the cube shown in Fig. 4. The X, Y, and Z axes of the cube were displayed in red, green, and blue. The evaluation weights for each element were represented by the intensity of the display.
- (c) By using database technology to construct a database from the analysis of evaluation factor shown in Table 1, extraction, addition, deletion, and the like of ideas while watching the cube it can be executed quickly. The results of manipulation will also be recorded.
- (d) By using the system described above, it will be easier to select ideas which match customer needs, and the evaluation values and target values which meet the customer budget as indicated in Fig. 5 will be improved in the manner shown in Fig. 6.

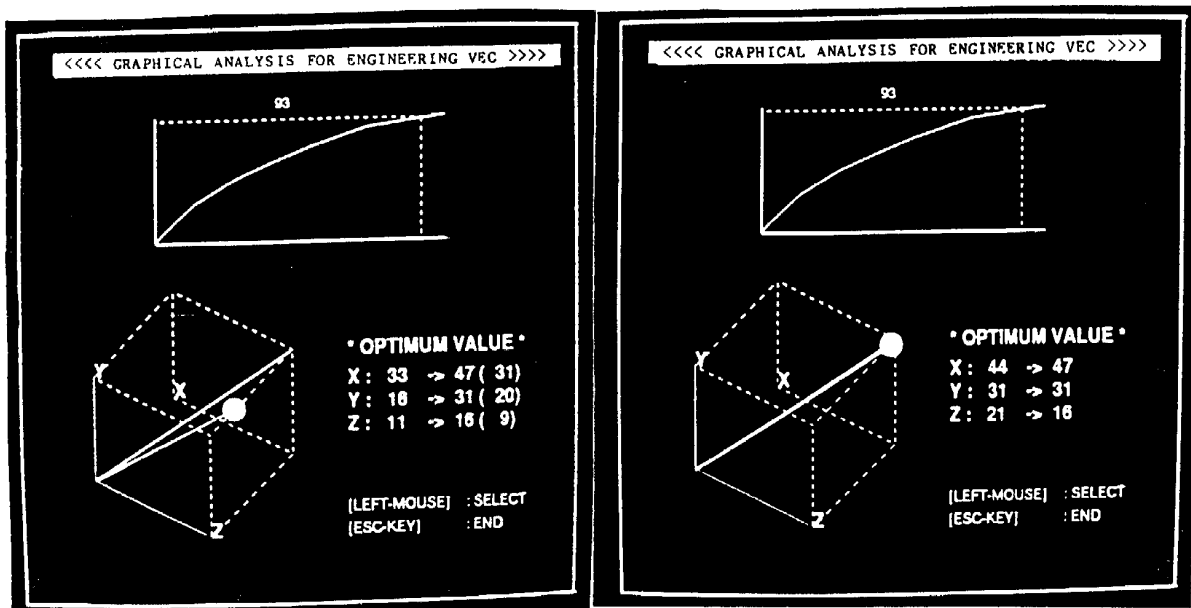


Fig. 5 Example of display for a serviceability evaluation factor analysis system

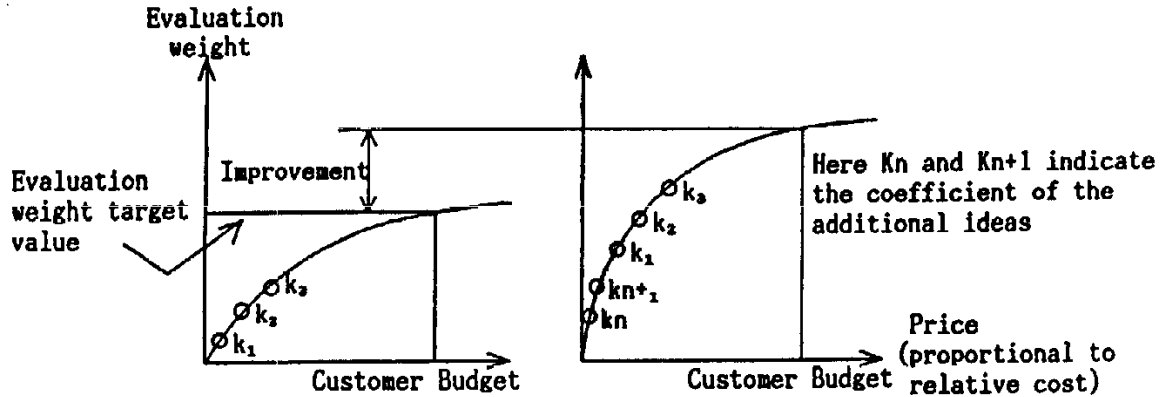


Fig. 6 Improvement of Evaluation weights through Addition of Ideas.  
Here  $K_n$  and  $k_n + 1$  indicate the coefficient of the additional ideas.

#### RESULTS

We have used this VEC technique in structural analysis evaluation, and have achieved the following results:

- (1) Extraction, addition, and deletion of ideas have been simplified through an interactive format with the customer, and it has also become possible to immediately judge results by the colors.
- (2) As a result, it has become possible to quickly and accurately grasp the needs from the customers point of view, so that serviceability and ease of operation have been improved. In examples of actual use, customer satisfaction and workability have improved by 1.60 times and 1.26 times, respectively.

#### CONCLUSION

This technique is an application of conventional product VEC activities to the engineering services field. Through the process from Quantitative comprehension of services provided by the supplier to selection of service items and extraction of ideas aimed at improvement of Customer satisfaction, we believe that this technique can be used to transform the non-uniform part of services (i.e., the simultaneity, temporary nature, differences in manpower requirements, etc.) into uniform items. Because of our lack of experience with VEC technique, we believe that there is much room for improvement in this VEC technique. Therefore, we have submitted this paper, and welcome opinions or criticisms from those of you who have more experience with VEC.

Because the services field is sure to increase in importance, and numerous types of analysis and studies are sure to be made, it is our intention to continue our efforts in VEC activities for this field.