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Value *Learned* . . . . Is Value *Earned*

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Abstract

The end result of "America's Awakening - The New Industrial Revolution", has got to be increased productivity. To meet the challenges of external competition, we are going to have to do more with the resources at our disposal. Concurrent with this need to increase output are the new administration's efforts to stem the tide of inflation by reducing budgets.

Some of industry's most valuable tools for "doing more with less" are the techniques of Value Engineering. A fundamental understanding of the value approach can help achieve productivity goals as they relate to goods and services, and in the motivation and management of the personnel who provide those goods and services.

This paper will identify and explain the techniques of Value Engineering, and discuss their application in the identification and elimination of unnecessary costs, through the organized Job Plan approach.

Value *Learned* . . . . Is Value *Earned*

Introduction

In its "Search For Profit", American industry is coming to realize, and appreciate more fully, the Plant Engineer's role in developing "bottom line" results! In its quest to do more for less - increasing productivity while reducing costs - industry is receiving encouragement to increase capital spending on the one hand, while being forced (by the economy) to reduce manpower and operating costs on the other.

It is in this challenging environment that the Plant Engineer must continue to provide the workforce every necessary facility and equipment to do its job, with even more emphasis on operating and other "costs of ownership". To perform this function efficiently and effectively, the Plant Engineer must use every tool at his disposal to assure that necessary products and services are identified, specified, procured, delivered, and installed on schedule and within budget.

While many of the methods used to accomplish these ends are known and have been well applied over the years, there is a discipline which will further increase the Plant Engineer's effectiveness on the job! Value Engineering encompasses these techniques, adds a few new elements, and results in a more organized approach to the identification and elimination of unnecessary costs.

Value Engineering

What is it?

Value Engineering has been defined as the *systematic* application of recognized techniques that:

1) identifies the *function* of a product or service,
2) establishes a value for that *function*, and
3) endeavors to provide that *function* at the lowest possible cost without diminishing performance or quality.

The purpose of this paper is to discuss these techniques, as they are applied through an organized approach called the Job Plan. The following glossary will provide some familiarization with terms generally associated with the subject of Value Engineering.

Value Assurance	the application of VE techniques during the conceptual and development stages, in order to effect a cost avoidance.
Value Improvement	the application of VE techniques to products or practices already in existence in order to effect a cost reduction.
Value Analysis/ Value Control	synonomous with value engineering.
Function	the normal or special action or purpose for which a product or practice was designed.
Basic Function	the characteristic of a product or practice which defines the reason for its existence.
Secondary Function	the characteristic of a product or practice which enables it to perform under conditional requirements.
Value	the appraisal of a product or practice resulting from a comparison of that item to alternate methods for satisfying a user need.

The major difference between value engineering and other activities concerned with the reduction of product or practice costs is the approach which is utilized to achieve the same or similar end results. In general, cost reduction methods are item oriented, i.e., the particular study subject is accepted as is, and alternate methods are developed to provide that item in a less expensive way. Value engineering is function oriented and each item is accepted as an expression of some function to be performed; it is only one of perhaps many ways to provide a specific need. As can be seen in Figure 1, the VE approach will generally lead to a larger number of alternatives than normal cost reduction methods.

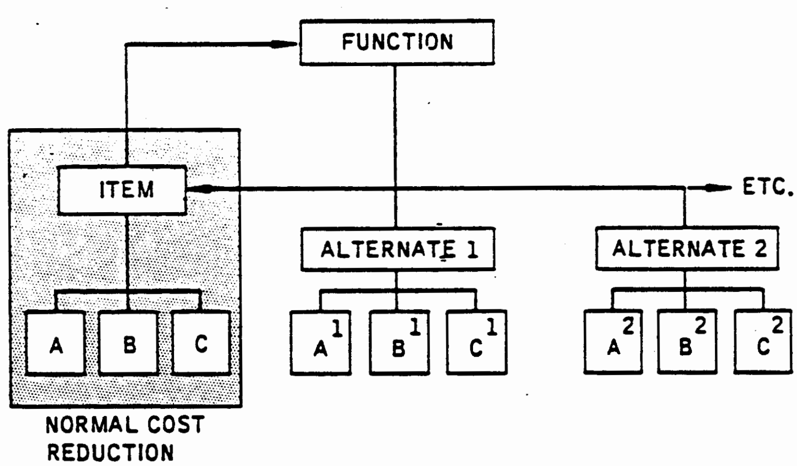

Figure 1 - Contrast of Value Engineering and Cost Reduction Approaches

The value engineering techniques are used to perform a complete analysis on any item selected for study, leading in specific phases to a definition and evaluation of function, generation of new alternatives, and development of a program to provide a feasible and economical system which will meet all necessary requirements.

The Job Plan

Right from its initial conception, one of the functions of the Value Engineering approach was to create an environment of "constructive discontent" as a substitute for the wartime emergency conditions which stimulated the many industrial innovations of that period. This discontent is bred by (1) accumulating costs, (2) determining function, (3) establishing a value for that function, and (4) comparing this value to the original costs. In almost every instance, this comparison will indicate that we are paying considerably more to provide required function than it is worth, which is a very real stimulus to seek improvements.

In order to assure some logical application of these steps, a Job Plan was developed which provides these elements woven into a five-phase framework. The development of the challenge takes place in the Information Phase, and is followed by an Ideation Phase, where ideas are generated for alternate ways to provide the required functions. From that point, the Job Plan provides guidance through Evaluation, Definition and Implementation Phases, starting with the step-by-step appraisal of the brainstorming ideas, and concluding with a completely defined proposal which is presented to key implementation personnel. Figure 2 is a typical Job Plan with general times spent in each phase by Solar Value Study teams.

The steps to be taken in each of these phases are outlined later in this paper but the most effective utilization of these techniques results when particular care is taken to plan and conduct the analysis by phase, in the recommended order. In brief, the VE Approach embodies a series of techniques to:

- BLAST — Removing all but required functions and defining them in simplest terms.
- CREATE — Exercising imagination to develop a number of alternate approaches.
- REFINE — Making these new ideas work under whatever program constraints exist (and cannot be eliminated).

It is an approach in which areas for study are defined, analyzed, and evaluated by a "systematic application of known techniques". Each Value Study seeks to answer the basic questions:

1) What is it?
2) What does it cost?
3) What does it do?
4) What is it worth?
5) What else will do the job?
6) What does that cost?

When the final answer indicates an approach less costly than the present method, and which will function as well "without diminishing performance or quality", the Value Study is complete and only the final implementation decision must be made by the appropriate company or customer management.

The Team Approach

The success of any Value Engineering effort is certainly a function of experience in applying the techniques, but equally as important is the degree of motivation which is accomplished during the study. The techniques in themselves are motivational, starting with the "constructive discontent" development, followed by the stimulation of creative thinking, and concluding with the satisfaction of a successful evaluation and presentation. A further advancement of these motivational aspects is the "team" approach generally practiced in any Value Study.

Case studies have shown that group response to motivational techniques is quicker and more complete than individual reactions. This is due in part to the psychological desire to be "one of the team", which tends to draw in all members of a group if any one reacts positively to a given stimulus.

The selection of three or more individuals to the VE "team" also adds considerable experience to the pool of talents available for concentration on the task to be performed. The limited knowledge of one individual is replaced by a depth of experience and breadth of approach (i.e. design, manufacturing, tooling, etc.) in excess of the total individual experiences. This is achieved by a "cross fertilization" of ideas wherein members of the group are stimulated by the suggestions of others, resulting in a greater exchange of ideas than would have been possible on an individual basis. Familiarization in a variety of areas also makes it possible for the team to gather information more intelligently than would be possible by any one individual.

In cases where the "team" cannot physically meet as a unit, the individual must simulate the team environment by soliciting the services of various specialists, and conducting portions of the study at one or more group meetings. These specialists can be company personnel, suppliers, or other consultants who have a service to provide. The technological explosion of the past decade has made it impossible for any one man to keep abreast of the latest developments in more than one field, and in many cases, even a relatively specialized field cannot be adequately covered. This rapidly expanding body of knowledge can best be interpreted by the specialist who can concentrate full time on the particular aspect of your problem, in a very specific area. In general, these men provide the details necessary to develop feasible practical approaches to the Value Study, and should be given every encouragement to participate as a "team" member.

In addition to the Job Plan and team approach, there are a series of techniques used throughout the Value Study. The following are some which will be identified as we progress through each phase of the Job Plan:

1) Determine and analyze costs.
2) Get all the facts, from the best sources.
3) Develop the team approach.
4) Use the VE Job Plan.
5) Define the function.
6) Evaluate the function.
7) Apply imagination.
8) Define and apply program constraints.
9) List alternative approaches, identify good and bad features.
10) Exercise experienced judgment.
11) Use specialty vendors and company specialists.
12) Utilize standard parts and practices.
13) Work on specifics, avoid generalities.
14) Verify technical and economic feasibility.
15) Determine implementation requirements and cost.
16) Identify and overcome roadblocks.
17) Challenge requirements.
18) Spend company money as you would your own.
19) Develop an implementation plan, with schedules.
20) Exercise salesmanship, and be diplomatic.

Phases Of The Value Study

I) Information

Cost Analysis

Once a potential study has been selected and the "What is it?" has been answered, the team must DETERMINE AND ANALYZE COSTS. Solar publishes a monthly "cost trend" report which lists detail costs by program code, part number and MO (Manufacturing Order) number. The costs are provided in terms of material, labor and burden for actual dates, lot sizes and direct accumulated hours. This information can be used to analyze costs by elements or categories for all in-house products or services. Costs of purchased parts are generally obtained from the cognizant buyer. If the item under study has never been manufactured, or standards established, and actual cost history is not available, all appropriate drawings, travelers, etc. should be forwarded to the Estimating Department, and a formal quote requested.

Additional costs for equipment "debugging", product sampling, and other inspections and test should also be accumulated, and special processing or handling costs must also be identified and segregated for use in later phases of the Job Plan. Site preparation, including relocation of water and electrical lines and special storage or space requirements should also be included. Many costs cannot be isolated, but efforts should be made to identify what would be spent for such things as preparing Purchase Orders, inventory cost per detail, transportation costs per traveler move, etc.

"User" costs in terms of power, material and equipment utilization, maintenance (including spare parts) and other factors must also be considered. A common wooden pencil, for instance, which is purchased for 5¢, costs 53¢ in labor for sharpening over its "life cycle". It also requires a "capital investment" in a sharpener, and perhaps even a wastepaper basket to accommodate the "scrap".

In general, the more complete cost information leads to the better Value Study results, due to a fuller understanding of the required operations, and a deeper appreciation for their impact on the total cost picture.

Additional Information

Just as cost data should come from Cost Accounting, information on fabrication operations should come from the Shop Foreman, or other specialists involved with that particular facet of the total task. In order to assure a complete and successful Value Study every effort must be made to GET ALL THE FACTS, FROM THE BEST SOURCES. No analysis would be complete without information regarding contract quantities and delivery schedules, special contract clauses, equipment versatility ("user" potential), loading factors, life expectancy, maintenance schedules, and other details. Discussion with cognizant personnel from Contracts, Marketing, Production Control, Manufacturing, and other areas will generally lead to a clearer understanding of each project, and could result in some potential problem solutions, since the "man on the job" very often has ideas which could simplify his work.

Additional tools necessary for the complete Value Study would be detail drawings, travelers, process specifications, and, as appropriate, sample hardware and/or operating materials, plus reliability and quality control information. If the project is system rather than hardware oriented the same general approach would apply, except detail drawings and process specifications, etc. might be replaced by departmental procedures, flow charts, standard practices, policy statements, and any other information which would describe the functions to be performed, and the methods used to do so, with their associated costs.

Team Organization

While information on the present approach is being gathered, and a preliminary analysis is being made to determine high cost areas, a concentrated effort should be made to DEVELOP THE TEAM APPROACH. Ideally, team members would be selected who have some background in the areas to be investigated, but not necessarily on the specific project which is under study. Past experience has indicated that individuals who have been too intimately involved in a project have a tendency to dominate the team activity and contaminate the approach with foredrawn conclusions. These men certainly are specialists in their areas, and should be consulted, but the team must be cautioned to identify and separate fact from opinion.

An individual working alone on a VE study can develop the team approach by establishing a working "project" relationship with key individuals in the departments which provide information for him, and bringing them together for a joint meeting during the brainstorming sessions, and in the final evaluation of recommended courses of action.

After a Task Force has been established, a team captain is elected, to act as a contact point for personnel involved and to organize the subsequent Value Study activity. The most effective method for this organization is to USE THE VE JOB PLAN to develop the team approach and establish schedules.

An estimate is made of the time to be spent in each phase of the Value Engineering Job Plan, allowing for project completion within the time allocated to the Study. If a completion date has not been previously established, this approach will provide the necessary information.

The most successful application of the VE techniques is a function of how well the Job Plan is followed. Many teams will tend to suggest solutions long before all the information is known. The Job Plan should be used to force a step-by-step analysis, to insure that the time spent in each phase will be concentrated in those areas which have the greatest potential for return. Unguided effort will only result in wasted time and ineffective analysis.

The Functional Approach

As indicated earlier, Value Engineering is *function* oriented, and differs from normal cost reduction activities in that each item is studied in light of the *function* which it is to perform. Once sufficient information has been collected to DEFINE THE FUNCTION, the physical characteristics of the item under study serve only to illustrate one way in which the function or functions can be accomplished. The item also serves to define the interfaces and some of the conditional requirements under which it must operate.

Those functions which serve only to meet conditional requirements are classified as secondary functions; those for which the item was designed, and necessary or essential to the required performance are termed basic functions. When an analysis is made on a detail level, there will normally be only one basic function but there may be many secondary functions. In any evaluation of functions, the criterion that only basic function has value should be applied.

Functions should be defined in only two words - a noun and a verb. In most cases this will not come easy, and the tendency will be to describe rather than define. A two-word definition will keep the approach simple, and there will be less confusion in subsequent discussions of function. More than two words will generally lead to an explanation (how) of performance, while the exercise in using just a noun and verb will generate a clearer understanding of what the item really must do to be of any value.

A careful analysis of the Task Force project will result in a list of all functions, then these will be classified as basic or secondary.

This analysis is best performed by using a matrix to list components and functions. In the first example that follows, each component has one function, but in an actual study each may have several, as shown in Figure 3, taken from an actual Task Force Study.

Functional Definition

Assembly: Pencil

Component	Function	B/S
Lead	Makes Marks	X
Wood	Supports Lead	X
	Provides Grip	X
Eraser	Removes Marks	X
Ferrule	Joins Components	X
Paint	Identifies Product	X

By asking why (higher level) and how (lower level) functions are performed, the team will derive additional information on the study item, and perhaps expand the project scope by developing a functional definition at different levels of abstraction. For example, if the team was to analyze a household refrigerator, its function could be defined as "provide cold", "preserve food", "prevent spoilage", etc., depending on whether the team chose to confine its analysis to the cold producing type refrigerators, or expand to some other ways to preserve food (as it is - canning, chemicals, etc.), or prevent spoilage (drying, special hybrids, etc.). If we asked why we would want to "prevent spoilage", and eventually came to the conclusion that this all led to "provide nutrition" (over extended periods of time), the team could find itself exploring food pills, etc., and develop a program to eliminate the need for refrigerators and all other "preservation" type devices. If the team worked in a refrigerator manufacturing facility, however, such an approach might not be conducive to long-term employment. It is, therefore, most important that the team define the working framework within which functions will be analyzed.

The next step in the Value Study is to associate the known costs with the various functions which have been defined. For our pencil these are: lead - 1.4¢, wood - 2.6¢, eraser - 0.3¢, ferrule - 0.4¢, paint -0.3¢. Those costs not contributing to basic function performance (3.6¢ = 72%) represent the poorest value, and should be given the highest priority in the search to eliminate unnecessary costs. In cases where portions of one detail's cost contributes to the function of another (for instance, holes in one part to mount another) the individual part costs should be divided and allocated to the function which they support.

Once this analysis has been completed the team is ready to EVALUATE THE FUNCTION, and determine some answer to the question "What is it worth?" Functional evaluation may be conducted by comparison of present costs to those of other items which accomplish the same or similar functions. It may also be derived by calculation, if the parameters under consideration are measurable in terms of dollars ($/#, $/ft., etc.). For our pencil, we pay 1.4¢ for approximately 7 inches of lead, (which provides our basic function), or 0.2¢/inch.

Cost comparison charts and mathematical relationships can also be used to establish a dollar figure for each function. If the Value Study under consideration is relatively complex, it may be more appropriate to define and evaluate functional areas, rather than analyze each detail and its inter-relationships with the total assembly and other details.

II) Ideation

After sufficient information has been collected and analyzed to define and evaluate functions, the Task Force team is ready to enter the second phase of the Job Plan, where ideas will be generated to provide alternate ways of performing required functions. In order to attain a maximum output from this phase, positive steps must be taken to develop a truly "creative" atmosphere before the actual conduct of any brainstorming sessions. This can generally be accomplished by giving the team several sensitivity exercises, and causing them to participate in "warm-up" sessions. The importance of suspending judgment and concentrating on a variety of ideas (flexibility), and as many as possible (fluency), must be developed early in the Ideation phase. When the captain feels the team is "primed" for the brainstorming session, the time has come to APPLY IMAGINATION to the project.

First the list of defined functions should be reviewed and priority established for those which will be explored. A separate brainstorming exercise is then conducted for each function, and a list of ideas recorded. Experience suggests that each idea be recorded on a separate slip of paper to make evaluation in the next phase somewhat more convenient. Ideally, at least two brainstorming sessions will be held, with at least a one-day "break" between them. This allows an "incubation" period before the complete review of ideas, at which time additional suggestions are stimulated by organizing the session according to the design approaches represented by the results of the first session.

III) Evaluation

The first step in the evaluation of the brainstorming results is to arrange the individual ideas first by function, then by general design approach. This can be best accomplished by preparing a chart or matrix, so that each idea can be reviewed in relation to the others which were generated. A typical matrix is illustrated in Figure 4, which is taken from the Expansion Joint Task Force report mentioned earlier. Note that several of the ideas could enhance more than one function. A further analysis of the "new concepts" selection would result in a variety of design approaches in addition to the material change and bellows design shown.

To bring the evaluation down from the "sky blue", the team must next DEFINE AND APPLY PROGRAM CONSTRAINTS to the ideas being reviewed. The parameters under which the system must operate should be established, and in the first analysis, those which cannot meet required conditions should be set aside. Requirements which appear unrealistic should be challenged, and the evaluation based on those which cannot be changed or eliminated.

Next, the team should make every effort to minimize or eliminate the undesirable elements, and associate a relative cost to each of the feasible approaches, in terms of the basic idea, and those modifications necessary to make the ideas useable. In some cases the total cost would be less if the basic idea was simplest, but in other instances the team could find a somewhat more expensive basic approach that could be implemented with little or no modification, making the total cost less! Taking our pencil example, if our project were limited to "deposit lead" (how does a pencil "make marks"?), we could develop costs for a mechanical pencil system. Such an analysis would show that while the initial investment for a holder was high ($2.99), all sharpening (labor) costs would be eliminated, and actual recurring costs per dozen pencils would be reduced from over $7 to approximately 72¢ . . . a 10/1 factor!

If the project were expanded to the "system" which includes paper on which pencils "make marks", it turns out the cost of a steel stylus and pressure sensitive paper is competitive, with the further benefit of again eliminating the labor-intensive sharpening operation.

These ideas which can be made to work are further evaluated, and a recommended plan would be to LIST ALTERNATIVE APPROACHES: IDENTIFY GOOD AND BAD FEATURES OF EACH. As an example, for the same "usage", wooden pencils occupy over 10x the storage volume of equivalent leads needed to support the mechanical pencil system. The wood system would have higher reliability, however, because of the multiple unit "redundancy" as opposed to a single mechanical holder.

While these ideas are being evaluated, the team should EXERCISE EXPERIENCED JUDGMENT in determining feasibility and relative costs. Here again, the teams will need to search out additional information, and should USE SPECIALTY VENDORS AND COMPANY SPECIALISTS to assist in the appraisal and modifications (if necessary) of the proposed approaches. The ideal situation would be to draw the implementing departments into technical feasibility efforts, thus paving the way for full acceptance at some later date.

As ideas are developed into workable solutions every effort should be made to UTILIZE STANDARD PARTS AND PRACTICES wherever possible. This will generally lead to lower costs for "off the shelf" items, and better delivery. It will also reduce requalification costs to a minimum, since most standard items conform to commerical and military specifications.

At the conclusion of the Evaluation Phase, the team should have relatively firm design concepts documented, and some record of the decisions which were exercised in their selection.

IV) Definition

The next step in the development of workable less costly alternatives is the preparation of a detailed description of each proposal. This should include a drawing or layout, preliminary planning, and a written summary of processes, purchased materials, etc. In this area the team should WORK ON SPECIFICS - AVOID GENERALITIES. These systems definitions should then be taken to the groups responsible for implementation, and their input solicited to VERIFY TECHNICAL AND ECONOMIC FEASIBILITY. Their suggestions regarding necessary changes should be discussed and evaluated to DETERMINE IMPLEMENTATION REQUIREMENTS AND COSTS.

In some cases the responsible personnel in these departments will display a natural "pride of authorship", and might be reluctant to change, or even to discuss the team recommendations. This will require the team to IDENTIFY AND OVERCOME ROADBLOCKS, and recognize the fact that suggested improvements are often mistaken for criticisms, causing a negative reaction. These reactions are often buried in a series of unreasonable restrictions, severe requalification costs, or a multitude of reasons why the suggested changes cannot be accomplished in the proposed manner. The team must CHALLENGE REQUIREMENTS, and perform a functional analysis on the tests, etc. All impositions that appear excessive or unnecessary should be detailed for a further review on an objective basis. Experience has shown that even our customers (including the military) are willing to change specifications if dollars can be saved at no sacrifice in necessary function, performance or quality.

After the proposed ideas have been reviewed and approved by the responsible departments, the implementation requirements must be organized to indicate cost and schedule impact. This information should then be forwarded to the Estimating Department, and the results of their analysis used to develop a "Breakeven Curve". In our example, the simple mechanical holder pays for itself in less time than it takes to "use" 6 wooden pencils, or less, if prorated sharpener installation costs are included. In the final analysis, the team should discuss all proposed ideas with the Estimator, to insure that costs for excessive inspecting, exotic tooling, etc. are not being added without good reason. We must SPEND COMPANY MONEY AS YOU WOULD YOUR OWN, and assure the most practical approach is being reflected in the estimate.

The Breakeven Analysis must take into account total implementation costs, unit price differential and program quantities. This latter data must be used on a realistic effectivity, incorporating the estimated schedule for accomplishing necessary changes. With this information the team should next DEVELOP AN IMPLEMENTATION PLAN, WITH SCHEDULES, to indicate actions which must be accomplished, by whom, and when. "Cost of Implementation" data can also be prepared, to indicate criticality of the implementation schedule and its impact on the effectivity of items incorporating the proposed changes

V) Implementation

The first steps in the implementation of any change should have been accomplished much earlier in the Job Plan - when technical and economic feasibility were established by the responsible project personnel. This ideally would have "greased the skids" so that implementation follow-up might be a rather routine matter, but generally a careful plan to accomplish changes must be developed and implemented.

In rather rare cases the proposed changes, or portions of them, may be incorporated during the course of the Value Engineering Study, depending on the complexity of the change, and the reception by the affected departments. If the proposed changes can solve a problem, or have an immediate impact with a minimum change effort, the chances of a quick implementation are good. The normal case will require the development of interest at a higher management level, however, and project information must be disseminated in the form of a final report and presentation. The written report is reviewed by the various affected department managers, and their comments incorporated into the implementation plan. Quite often the VE Task Force will be called upon to provide leadership and back-up data in the follow-up function. This is the time to

EXERCISE SALESMANSHIP, AND BE DIPLOMATIC. The critical point of implementation lies in convincing the program managers that the proposed changes are beneficial to both the company and the departments involved.

Implementation follow-up is maintained by scheduling periodic reviews to determine progress and identify problem areas as soon as possible. Final culmination of the VE effort is in the personal satisfaction which comes with the incorporation of the proposed changes. At this point in time, the VE Task Force can look back at a job "well done", and look ahead to the areas where the application of Value Engineering techniques will enhance the company's profit and competitive position, through the identification and elimination of unnecessary costs.

Conclusion

As in our example, the techniques of Value Engineering, applied in an organized way to even simple "systems" can: (1) reduce original installation costs, (2) reduce inventory and storage costs, (3) save space (and energy) and (4) reduce operating and total costs, without sacrifice to necessary function or quality. If we *learn* how to apply these techniques effectively, we can do more with less, and will improve our productivity, enhancing every other effort being made to *earn* our niche in, and contributing to, "America's Awakening - The New Industrial Revolution".

Team No. ____________________

Project ____________________

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SOLAR TURBINES INTERNATIONAL

Value Engineering
Job Plan

Team Members

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Phase	Information		Ideation	Evaluation		Definition		Implementation		
Hours	8	4	4	4	4	4	4	4	4	3
Date										

Information	Ideation	Evaluation	Definition	Implementation
What is it? What Does it Cost? What Does it Do? What is it Worth? .Determine and analyze costs .Get all the facts from the best source .Develop the team approach .Define and evaluate function	What else will do the job? .Apply imagination Try - .everything .anything Be - .creative .spontaneous .fluent .flexible .original Then - .simplify .magnify .eliminate	What Does that Cost? .Organize your ideas .Define and apply program constraints .List good and bad features .Put a dollar sign on all decisions .Exercise judgment .Use specialty vendors & company specialists .Utilize standard parts and practices	.Work on specifics avoid generalities .Verify technical and economic feasibility .Determine implementation requirements and costs .Identify and overcome roadblocks .Challenge requirements .Spend company money as you would your own .Develop an implementation plan, with schedules	.Prepare a written report .Consider the use of models .Discuss report with affected departments .Include latest forecasts and pertinent data .Include "breakeven" analysis .Develop flip charts with highlights .Make an oral presentation to management .Exercise salesmanship, and be diplomatic .Be prepared to spearhead follow-up

VALUE ENGINEERING TASK FORCE

FUNCTIONAL DEFINITION

16" - 150 P.S.I.G. SELF EQUALIZING EXPANSION JOINT ASSEMBLY

DETAIL

FUNCTION BASIC / SECONDARY	B	S	-1 Flange	-2 End Ring Assy.	-3 Equalizing Ring Segment	-4 Bellows	-5 Weld End
Compensates Length	B					X	
Increases Cycle Life		S		X	X	X	
Decreases Spring Rate		S				X	
Limits Compression		S		X	X		
Protects Bellows		S		X	X		
Provides Attachment		S	X				X
Limits Expansion		S					

Note: This function is not performed by any detail of the present design. The task force suggests this function be given consideration in future designs.

Figure 3 - TYPICAL FUNCTIONAL DEFINITION CHART

VALUE ENGINEERING TASK FORCE

FUNCTIONAL EVALUATION

16" - 150 P.S.I.G. SELF EQUALIZING EXPANSION JOINT

Secondary Functions	Material Change	Bellows Design	New Concepts
Increases Cycle Life	Better Material In Fatigue	Material with Improved Properties	. Multi-Ply Construction . Revised Root Ring Design . External Sleeve and Root Ring . Revised Tube Welding Methods (Spiral Wrap)
Decreases Spring Rate	Higher Tensile Material to Reduce Thickness	New Shape-Pitch Span Relationship	. Multi-Ply Construction
Limits Compression		Bellows Shape Redesign	. External Sleeve With Root Rings . Internal Restraints
Protects Bellows			. Sleeve . Simple Sheet Metal or Wire Mesh Cover

Figure 4 - TYPICAL FUNCTIONAL EVALUATION CHART