VE - A STEP CHANGE TO DESIGN INNOVATION

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ABSTRACT

This paper demonstrates a novel approach on how Value Engineering (VE) principles have been successfully utilized to develop and implement a new high efficiency filtration technology for a U.S. Department of Energy (DOE) project. This technology when implemented would have a significant positive impact on the environment, create new market opportunities for the manufacturer of the filtration system components and provide an overall Life Cycle Cost (LCC) savings to the customer.

1.0 INTRODUCTION

The traditional approach in engineering has been to accept the criteria given by the customer and develop them further during the design rather than question them at the outset. The criteria normally dictate how to do the work rather than what functions to accomplish. This approach results only in improving the performance of the existing system and inhibits creative thinking. On the other hand, the customer should be exposed to the VE technique, which through the process of function analysis, results in developing criteria based on what functions to accomplish rather than how to do the design. The VE approach is beneficial to the customer and the designer as it helps to align him and the design team on the functions essential to accomplish the project objectives. This encourages the design team to explore new avenues to design innovations which could result in a step change from existing design methods.

To illustrate this approach in more detail, this paper highlights a recent example of using the novel application of the VE principles in one aspect of a design, the environmental control system that serves the most radioactively contaminated areas of a nuclear facility designed by Fluor Daniel, Inc. (FDI) for the U.S. DOE. Nuclear facilities vary in size, shape, complexity and include environmental, public and process considerations, as well as specific project criteria and design constraints. In general the nuclear industry has taken a very conservative approach to the facilities they design and have been reluctant to change and investigate or develop new technologies. This has prompted some customers to use the "SLOW" (Same Lousy Old Way) rather than the "FAST" (Function Analysis System Technique) approach in the design of nuclear facilities. This paper discusses the use of modified a VE technique and the benefits of VE being applied at the conceptual design stage in a nuclear environment.

As part of the initial alignment process with the customer, the customer is exposed to the FAST, unique to VE. The FAST technique for process improvement has been used at FDI on several projects during early stages of design. It focuses on function analysis and creative brainstorming to investigate the potential for further development of some basic ideas and identification of additional VE studies.

The study in this paper illustrates the result of an overall function analysis and creative brainstorming exercise to identify potential areas of study for a billion dollar DOE project. The study represents an evaluation of one aspect of the design. Recommendations of the study changed the overall direction of the project. The innovative solution resulted in a first-of-a-kind design and its implementation could have a far reaching impact on the future design of nuclear facilities. The resulting technology development also had a very positive impact on the environment and the overall safety of nuclear facilities.

2.0 BACKGROUND

FDI was directed to use technology from existing DOE facilities, to the maximum extent possible, and to duplicate a similar plant at another DOE site for processing of nuclear waste. This dictated the criteria on how to do the design rather than what functions to accomplish. A conceptual design was done based on the customer dictated criteria and identification of major cost items. This approach resulted in only minor improvements in the performance of the existing design and inhibited creativity.

Since FDI was given a DOE preferred alternative for the design of the system, the author proposed that before detailed project design started that a systematic evaluation of the proposed conceptual design be done using the VE methodology. The customer was reluctant to change the existing system due to cost and schedule concerns, but was receptive to any new ideas that could potentially improve the design and make it more cost effective.

3.0 VE STUDY

3.1 PROJECT OBJECTIVE/SCOPE

The objective was to review the environmental control system for a nuclear facility being designed by FDI for the U.S. DOE and investigate areas of process improvement and potential for cost savings. The scope was limited to the environmental control system that serves the process cells, due to high cost and greater potential for process improvements.

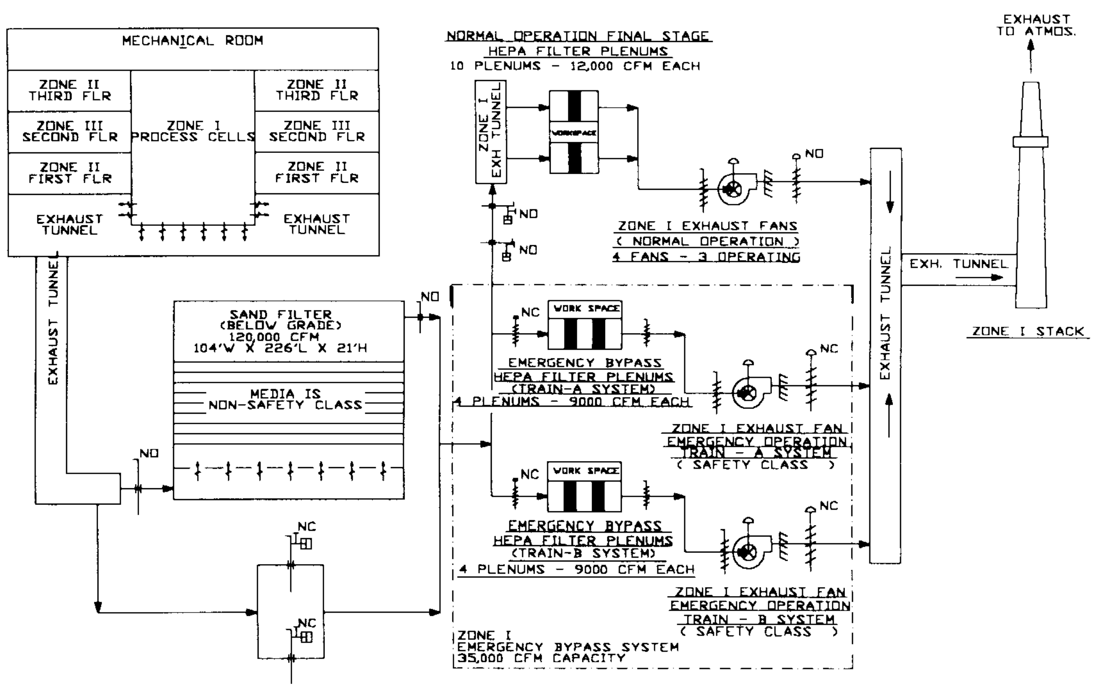

FIGURE - 1 Zone I Filtration System - DBS Filter Concept

3.2 INFORMATION PHASE

This DOE facility is used to vitrify nuclear waste in process cells designed to handle highly radioactive material. These process cells are served by an environmental control system, which controls the environment within the process cells and maintains confinement by preventing the radionuclides from escaping the building. This system is referred to as the Zone I Filtration System (Figure 1). In order to meet federal emission guidelines, the air exhausted from the process cells is passed through a minimum of two filtration stages. The customer dictated design used a Deep-Bed Sand (DBS) filter as the primary source of filtration.

The DBS filters are characteristically one-of-a-kind designs and this filtration technology has been in use since 1948. The DBS filter is enclosed in a concrete structure, partially underground (226 feet by 104 feet and 21 feet high), sized to handle 120,000 Cubic Feet Per Minute (CFM) of air. It consists of multiple layers of rock, gravel and sand which act as the filtration media. The air from the process cells flows through the DBS filter and a High Efficiency Particulate Air (HEPA) filter before being discharged to the atmosphere through the Zone I stack. By nature of its design, the DBS filter may not survive a Design Basis Earthquake (DBE). A post DBE system (Emergency bypass filtration system around the DBS filter) is in place in the event of DBS filter failure (Figure 1).

The VE team members were generally familiar with the overall project, so the time needed for information gathering was minimal. A rough order of magnitude cost estimate from the conceptual design phase was provided to the team. This was used to determine the cost/function relationships. Details of the cost estimate will not be discussed in the paper as the cost data are proprietary in nature, only comparison cost data are presented.

3.3 FUNCTION ANALYSIS

The function of the environmental control system is to prevent airborne releases of radioactive contamination to the environment during normal, abnormal, and accident conditions, to control the facility environment for the comfort of personnel and for optimum performance of equipment.

Three questions were asked before actually starting the Function Analysis process, the following responses represents a consensus of the team:

- What is the problem we are about to discuss?

  Review the high cost of the environmental control system serving the process cells and investigate areas of system optimization and potential for cost savings.

- Why do you consider this a problem?

  The conceptual design identified potential safety and reliability problems with the existing design. In order to satisfy all Design Basis Accident (DBA) conditions, the existing design was very complex and it also had a negative impact on the environment by generating waste that was difficult to handle and costly to dispose.

- Why do you believe a solution is necessary?

  A solution is essential that can provide a safer and more reliable system, minimize the waste generated and is potentially easier and more cost effective for Decontamination and Decommissioning (D & D).

Once the information on the project was digested by the design team, the problem was analyzed to determine those functional characteristics describing the problem using the active verb and measurable noun format. After listing all potential functions of the system and identifying the Basic function and the High Order function, the FAST diagram was developed as indicated on Figure 2. The FAST diagram identifies two Basic functions; Control Environment and Control Contamination; and the required secondary functions, and the associated support functions.

The team then considered the key aspect of Function Analysis, which was the determination of cost/function relationships; this would direct the team to the areas of greatest opportunity. Based on the cost/function model, the relative percent contribution of each important function was also identified on the FAST diagram. As the major costs and design problems were associated with the control/filter of contamination (Figure 2), it was

ENVIRONMENTAL CONTROL SYSTEM - FAST (DBS FILTER)

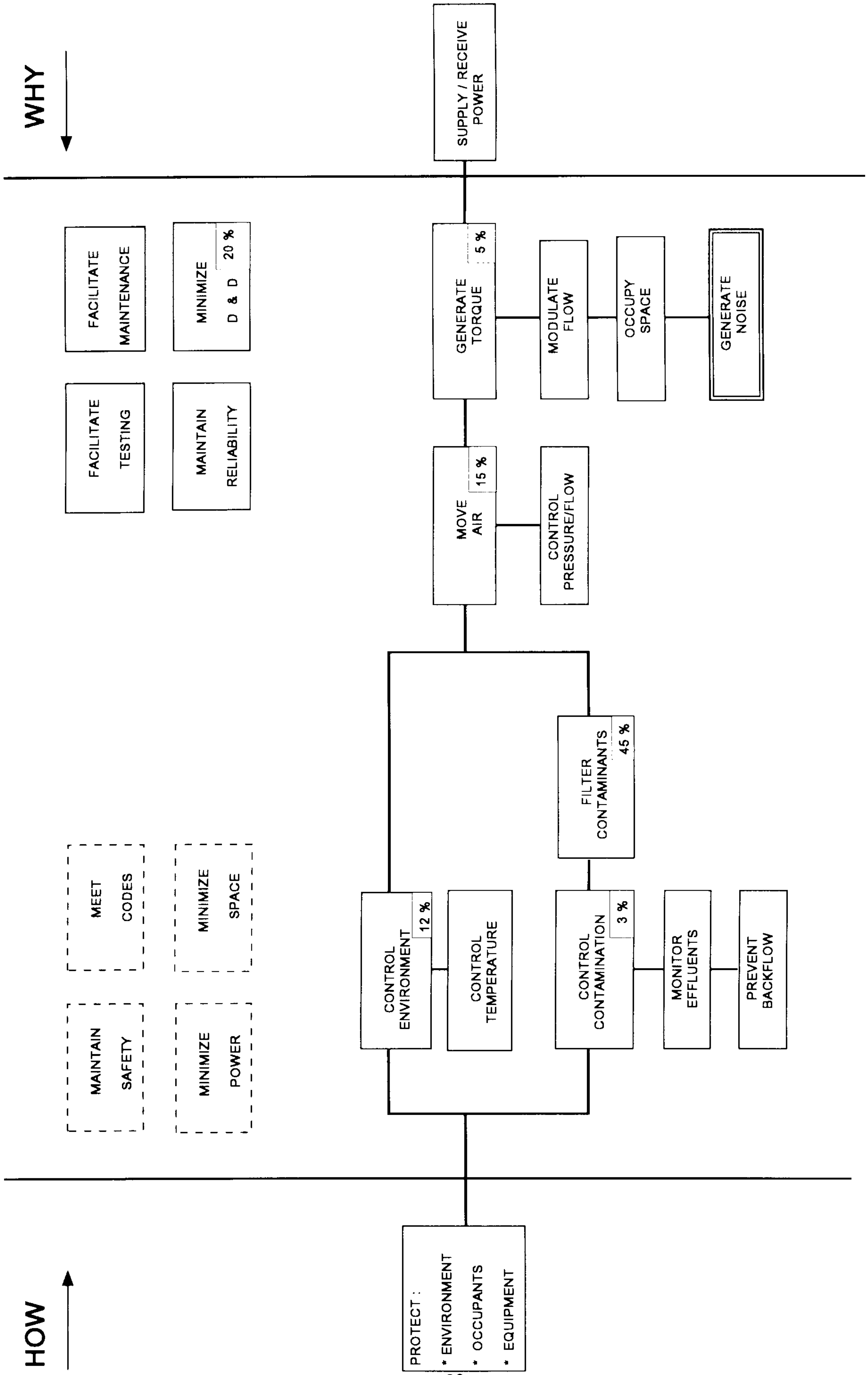

FIGURE - 2

decided that the primary effort should be spent on this basic function.

Since the major cost was associated with Filter Contaminants, it was evaluated further. Functions required to accomplish this task were identified and are shown on the FAST diagram indicated on Figure 3. This FAST diagram was developed to serve as a design tool in the selection of the filtration system and to identify potential areas of concern to the design concept. The All Time function identified as, minimize D & D, was also a major cost factor, but is dependent on the technology used to filter contaminants. The team consensus was then to investigate filtration systems that could also reduce the cost of D & D.

3.4 SPECULATION PHASE

The speculation phase was initiated with the golden rule of VE, "Challenge Everything". Simply asking the right questions could be a launching pad to problem solving. The function "Identify Technology" (Figure 3) redirected the line of thinking from the conventual technologies to the potential investigation of new technologies. The brainstorming process generated several ideas from wacky to wonderful, from silly to sublime. It also produced the standard forms of filtration systems available for the nuclear industry, but one new and potentially promising idea surfaced that presented a challenge to the team - the application of High Efficiency Metal Fiber (HEMF) filters. These filters have been in use in the chemical and food industries, especially in Europe and could potentially be used for this application. No judgement was passed except that it should be evaluated in the next phase.

3.5 EVALUATION PHASE

The purpose was to evaluate, criticize and test the ideas generated during the speculation phase, to determine if ideas would work and to identify the most promising concepts and determine if the ideas would be cost effective.

The ideas generated during the speculation phase were screened, sorted and combined based on a quantitative criteria and the project requirements. The list was then narrowed to the following filtration technologies for further evaluation:

- DBS filter system (Existing System)
- Remote HEPA filter system
- Deep Bed Glass (DBG) filter system
- HEMF filter system.

FDI had designed nuclear systems based on the first three alternatives and had a design data base on these systems. Since the HEMF filter technology was new to most members of the team, there was a reluctance to add it to the list of options and a preference to stay with proven technology. Normal road blocks were presented, such as: "will not work", "never been done before", "its too risky", etc. The desire was to stay with the technology we were most comfortable with because it matches our expertise. The author suggested that many ideas can be made to work if certain problems are overcome. A problem should not be the cause for rejection until it is objectively evaluated. The feasibility of using the HEMF filter system was not obvious due to an overall lack of knowledge. It was suggested that more information was needed to develop this idea and that potential vendors should be contacted.

Several vendors were contacted and two indicated interest in supporting the development of the design concept. A qualitative judgement of this technology was based on the information provided by the vendors and data available from research work on HEMF filters.

Based on the criteria for the selection of the filtration system, the criteria matrix was developed to determine the relative importance of the criteria. The weight factor developed from the criteria matrix was used in the analysis matrix to determine the relative ranking of the different alternatives. The analysis matrix clearly indicated the technical superiority of the HEMF filter over the other alternatives, but it indicated some additional work would be required. In general this alternative could work, meet the safety and technical criteria and potentially have a lower D & D cost. The creative process of VE seems to have generated a new design concept that had the potential of having a very positive impact on the objectives of the project.

In most cases, cost reduction is considered the most important, or worse, the only evaluating factor. In developing the new technology, cost could be a major concern, but the existing design had some serious technical and safety concerns which could have had long term implications. Therefore, any solution could be cost effective if it was technically

FILTER CONTAMINANTS - FAST

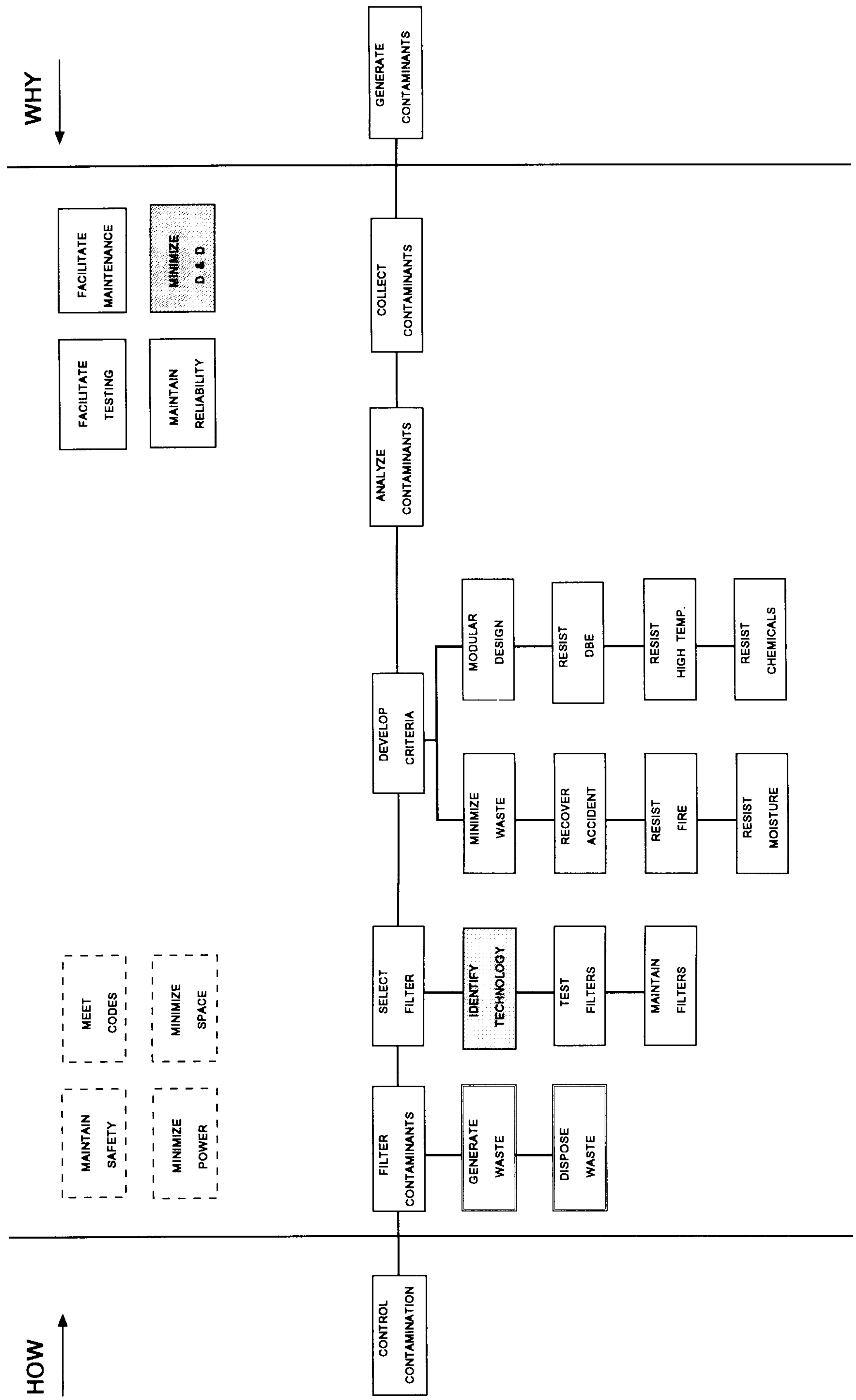

FIGURE - 3

superior, provided a long term solution, and had an overall life cycle cost savings.

3.6 DEVELOPMENT PHASE

The VE study took a unique turn at this point, since the team was dealing with a new technology, more detailed information, additional time and potential participation of the vendors was needed to further develop and refine this innovative idea. Since conceptual design was almost completed, the customer did not anticipate any major design changes at this point. The team had to tell the customer that his criteria were too restrictive and might have to be changed to accommodate new technologies, with potential impacts to cost (unknown) and schedule (estimated at 3 to 6 months). A novel approach was needed to make this concept feasible. The traditional approach would be to accept the criteria given by the customer and make minor improvements rather than question the criteria in the interest of meeting the project schedule. Rather than conclude the VE study, the team requested that an alignment session be held with the customer and FDI management to indicate the new direction the study had taken and the potential for a step change to the design of the environmental control system. This was a risk worth taking in order to provide "added value" to the customer. During the alignment session, the VE team convinced the customer and the FDI management that this idea was worth further investigation. The customer accepted the challenge, agreed to support additional work required to investigate this idea and any schedule impacts due to changes required to implement this design concept, if it proved viable. It was decided that this VE study would reconvene after development of the HEMF alternative design and final results would be presented to the customer and FDI management at that time.

Additional investigation of HEMF filters indicated that they have been successfully used for small capacity experimental type nuclear systems but none have been designed for a nuclear filtration system of the size (120,000 CFM) needed for this project. Vendor participation was essential if this concept had any chance of implementation, because it required development, testing, and certification to meet the nuclear codes and standards and for estimating the cost of the new concept.

The development process took approximately four months. During this period a conceptual design was completed using the new filtration concept developed in association with the vendors to the same level of detail as the existing DBS filter design. This was required to prepare a rough order of magnitude cost estimate for the new design concept. During this phase one vendor initiated the process of testing the filters and prepared for certification to meet the industry codes and standards. There was a certain amount of risk associated with this new technology, but it was demonstrated to be much lower than the existing design due to the reliability of the filtration medium and its ability to withstand all DBAs.

The installed cost of the HEMF filtration system was estimated to be about five million dollars less than the existing DBS filter design. It is anticipated that the cost of these types of filtration systems would decrease dramatically once this technology base was expanded to other nuclear applications. Based on the cost estimate, a life cycle cost analysis was performed to compare the two alternatives. The LCC analysis included the operations, maintenance and D & D costs and it indicated a savings of about 7.5 million dollars over the life of the facility. This technology is safer, and offered greater value to the customer because in nuclear systems safety is a primary concern. The other major benefits of this technology were that it offered a simpler and more reliable system that could withstand all the DBAs, did not require a redundant emergency bypass filtration system and required a much smaller building (100 feet by 60 feet and 40 feet high) to accommodate the filtration system.

The HEMF filters are enclosed in cylindrical vessels sized for 12,000 CFM each. This offers a modular design which can accommodate any future expansions. It also provided an order of magnitude reduction of the D & D cost, mainly due to the reduction of the overall waste (radioactive) generated by the system over the life of the facility. For D & D purposes, the DBS filter would generate about 8,000 cubic yards of radioactive waste compared to only 75 cubic yards of potentially less contaminated waste generated by the HEMF filters. The collection, processing and disposal of waste for the HEMF filtration system is much simpler and would have a significant positive impact on the environment.

3.7 PRESENTATION PHASE

On the basis of successful development of the HEMF filtration concept and LCC analysis, a formal presentation was made to the customer and FDI

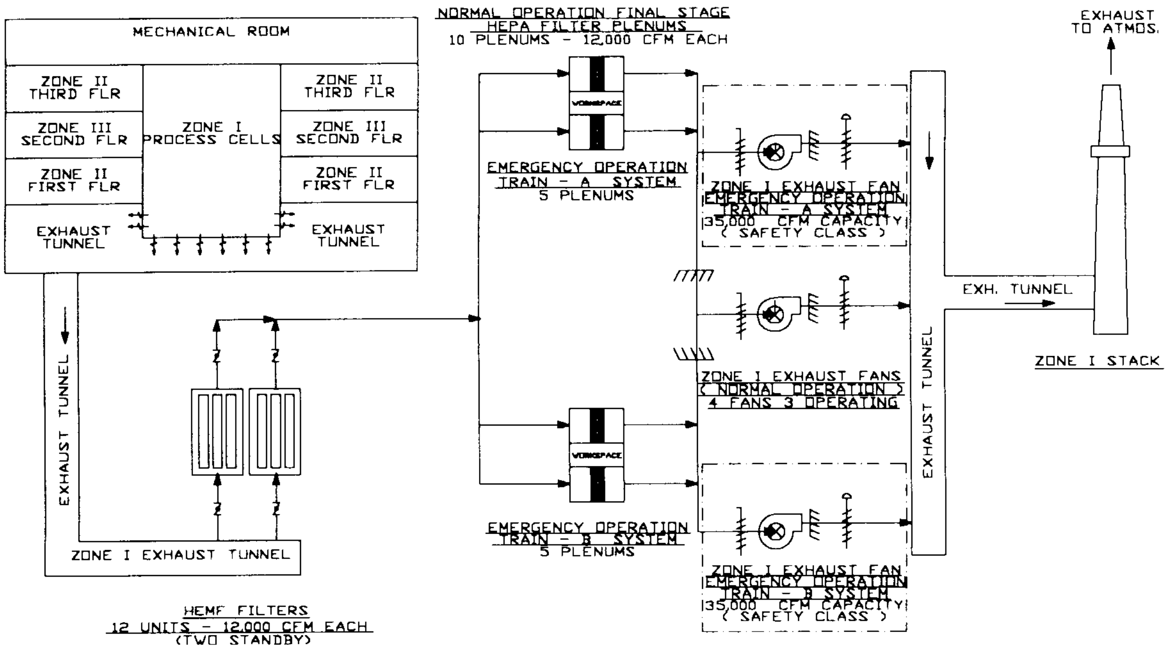

FIGURE - 4 Zone I Filtration System - HEMF Filter Concept

management on the results of the VE study along with an implementation plan. The overall impact to the schedule was minor in relation to the facility design program. Also, several other applications of this technology were identified which could have major implications on how future nuclear facilities are designed and built by DOE. Since this was a step change in technology, several additional presentations were made to the customer and FDI management. Final approval was given to implement the new technology into the design of the nuclear facility. It was also agreed that design would progress as this new technology was further validated through the testing and certification process.

3.8 IMPLEMENTATION PHASE

Several technical challenges were presented to the design team in implementation of this design concept. The implementation of this concept into the existing design took an additional six months and also required major changes to the criteria documents. The customer dictated criteria had to be changed from the DBS filter to a functional criteria in order to accomplish the required functions. New specification and testing procedures were developed for the HEMF filters. One filter manufacturer was prepared to handle the costs associated with the testing and certification effort because of the potential new market for this product.

The environmental control system was revised to accommodate the HEMF filters into the Zone-I Filtration System, the DBS filter was replaced with the HEMF filters and the emergency bypass filtration system was deleted (Figure 4). This system provided an optimum combination of performance, safety, reliability, quality and an overall LCC savings to the customer.

4.0 CONCLUSIONS

Developing and implementing creative ideas is an important part of the VE technique. Also, if process improvement and not cost reduction is the main objective, then the team focus changes from cutting cost to the search for new and challenging ideas. The function analysis approach encourages the VE team to explore new avenues to design innovations often leading to a step change from existing design methods, as was the case in this study. The VE format is also helpful in conveying the message to the customer, especially if it requires a step change from the "SLOW" to the "FAST" approach, that results in a better and cost effective way to accomplish the functions of the project. Application of VE at the conceptual design phase and prior to detailed design also saved design costs and improved project value. The value analysis process produced a greater understanding of the project and project objectives, and resulted in an improved design and an overall LCC savings to the customer.

Working with the customer, a creative design team and supportive vendors, a new technology was developed, tested and successfully implemented into the design. Value was maximized by providing the optimum combination of performance, safety, reliability, quality and cost from application of this technology to the customer. This step change in the filtration technology would also have a significant positive impact on the environment and the safety of nuclear facilities. By designing an innovative system FDI benefited from being the only company in the world to have this kind of design experience. A potential new market was established for the manufacturers of the filtration system components and it is anticipated that other nuclear applications will soon follow.

This paper demonstrates that through the creative process of VE, a responsive customer and the support of company management, it is feasible to take a step change to design innovation and stay one step ahead of the competition.