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MARKET INVESTIGATION AND MATERIAL EVALUATION OF CARTRIDGE FILTERS

FINAL TECHNICAL REPORT

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BY
JOHN M. DAUGHERTY
MICHAEL J. CLARK

PREPARED FOR THE:

US ARMY
BELVOIR RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
FORT BELVOIR, VIRGINIA 22060-5606

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Material Acquisition Support Division
1710 Goodridge Drive, T1-7-2
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A two-tiered market investigation was conducted for cartridge filters used in the 600 and 3,000 GPH Reverse Osmosis Water Purification Units (ROWPUs). The fielded ROWPUs use string-wound, depth filters. It is possible that different designs may be more effective than the current design. The two-tiered investigation involved a preliminary questionnaire to establish type of filters manufactured, followed with a detailed questionnaire to these manufacturers that manufacture cartridge filters which may be used in the target ROWPUs. It was found that pleated, porous cartridge filters provide improved performance in reusability, solids entrapment, and are in a reasonable cost range. The Government must test specific pleated filters with consistent input water to verify and/or compare their performance.

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MARKET INVESTIGATION AND MATERIEL EVALUATION OF CARTRIDGE FILTERS FOR THE FAMILY OF WATER SUPPLY EQUIPMENT	STUDY GIST

PRINCIPAL FINDINGS:

A two-tiered market investigation was conducted and it was found that pleated, porous filters are best suited to perform the pretreatment filtering function for the Reverse Osmosis Water Purification Unit (ROWPU). Pleated filters would replace the string-wound filters (often referred to as "depth" filters) now in use in fielded ROWPUs. The pleated filters are within the cost per unit range desired by the Army, can collect more solids, and offer a limited capability to be reused after flushing with water.

MAIN ASSUMPTIONS:

An assumption was made that filter manufacturers would provide data for the seven attributes asked about in the detailed questionnaire. For the "performance" attribute, data were not provided in sufficient detail to make specific comparisons among candidate filters. As a result, the evaluation contains a total filter score with and without the performance attribute.

PRINCIPAL LIMITATIONS:

The main limitation of the study was the failure of manufacturers to provide performance data about their products. This was not a total surprise since a standard input water quality is not available against which to quantify product performance.

SCOPE OF EFFORT:

The scope of this effort was to develop and conduct a two-tiered market investigation of commercial firms which produce filters that are compatible with the ROWPU pretreatment cartridge filter housing. Having received completed questionnaires, the data were analyzed, evaluated, and conclusions and recommendations drawn and documented.

OBJECTIVE:

The objective of this task was to conduct a comprehensive market analysis of commercially available cartridge filters that may be used in the pre-treatment section of the ROWPU. The market analysis will concentrate solely on this item.

BASIC APPROACH:

The contractor's expertise in system/hardware integration and the materiel acquisition process will be used to conduct the market analysis and materiel evaluation on the cartridge filters available for the ROWPU. This effort will develop an in-depth questionnaire, provide a comprehensive description of the cartridge filters available, and, in conjunction with

Government technical representatives, conduct an in-depth evaluation of these items resulting in a recommendation of the most promising cartridge filters.

REASONS FOR PERFORMING THE STUDY:

There may be commercially available filters which have longer life, higher solids removal efficiencies and may even be reusable. Use of different filters may improve the overall effectiveness of the ROWPU pretreatment section. A market investigation is necessary to determine the best type of cartridge filter for use in the pre-treatment section of the 600 and 3,000 gallon per hour (GPH) ROWPUs.

IMPACT OF THE STUDY:

The results of the study show that the use of pleated cartridge filters to replace string-wound, depth filters will improve the overall performance of the pre-treatment section of ROWPUs.

SPONSOR:

US Army Belvoir Research, Development and Engineering Center

PRINCIPAL INVESTIGATOR:

Mr. John M. Daugherty, Science Applications International Corporation

ADDRESS FOR COMMENTS AND QUESTIONS:

Commander
US Army Belvoir Research, Development and Engineering Center
ATTN: STRBE-FSE
Fort Belvoir, Virginia 22060-5606

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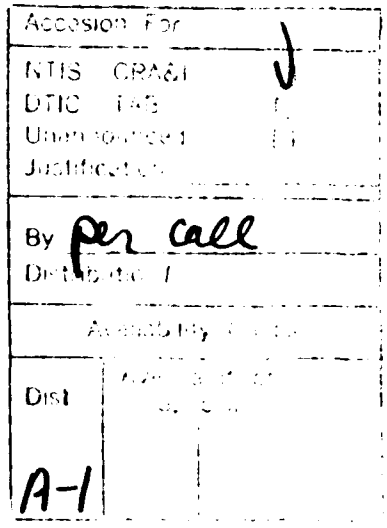

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SECTION 1
INTRODUCTION

1.1 BACKGROUND

The Logistics Equipment Directorate at the US Army Belvoir Research, Development, and Engineering Center (BELVOIR) is responsible for the research and development of various Army materiel projects. One of these projects is the Family of Water Supply Equipment, which includes the 600 gallon per hour (GPH) Reverse Osmosis Water Purification Unit (ROWPU) and the 3,000 GPH ROWPU.

The Army is presently using Filterite filament wound (or commonly called "depth" filters), 5 micron (nominal) cartridge filters as its final filtration step in the pretreatment section of the ROWPU. These filters are consumable items which must be replaced once the pressure drop through the filters becomes too great - normally 20 pounds per square inch (PSI) differential pressure. There may be filters commercially available which have a longer life, higher solids removal efficiencies and may even be reusable. Use of these types of filters may improve the overall effectiveness of the ROWPU pretreatment section. A market investigation of commercially available cartridge filters is necessary to determine the best type of cartridge filter for use in the pretreatment section of the ROWPUs.

1.2 OBJECTIVE

The objective of this task was to conduct a comprehensive, two-tier market analysis of commercially available cartridge filters that may be used in the pretreatment section of the ROWPU. The Statement of Work for this task is at Appendix A.

1.3 STUDY APPROACH

Science Applications International Corporation (SAIC) expertise in system/hardware integration and the materiel and technologies process was used to conduct a market analysis and material evaluation on the cartridge filters available for the ROWPU. In this effort:

- a general questionnaire was developed and provided to industry to determine the general range of filters and firms which could potentially provide filters.
- an in-depth questionnaire was then developed which included a description of the ROWPU pretreatment functions.
- responses from the detailed questionnaire were analyzed and evaluated, and conclusions and recommendations made for the continued development of the most promising filters provided by industry.

SECTION 2
LITERATURE SEARCH

2.1 IDENTIFICATION OF MANUFACTURERS

The Government Technical Point of Contact (TPOC) conducted a comprehensive review of available literature to identify firms that might provide candidate cartridge filters. Materials, such as trade periodicals, industry registers, and reference publications researched by the contractor, SAIC, provided an excellent cross-referenced list of manufacturers. The study team, using these reference materials, was able to narrow the initial list of manufacturers by eliminating those whose products clearly fell outside the range of interest of this investigation.

Concurrently, an announcement was published in the Commerce Business Daily (CBD), describing the purpose of the market investigation and inviting interested firms to participate. Several firms responded and were added to the growing list of candidate firms. The final list for the Initial Questionnaire contained 173 firms.

The Foreign Intelligence Office (FIO) at BELVOIR was formally queried by SAIC. Two pieces of information were obtained from the office, but neither one fit our scope. The first was a Japanese firm that produced Reverse Osmosis Units, however, there was no mention of cartridge filters or any technical data to evaluate the system. The second was an Australian firm that produces what it calls Crossflow Microfiltration Technology (CMF). This is a complete Reverse Osmosis system that is out of the scope of this project, but which might hold some promise for future testing. Information on these foreign systems, which is classified, may be obtained from the FIO.

SECTION 3
DESIGN OF QUESTIONNAIRES

3.1 THE TWO-TIER QUESTIONNAIRE APPROACH

The information necessary to accomplish a market investigation of this type depends upon the willingness of the manufacturers to participate. In order to increase the probability of wider participation, a two-tier questionnaire approach was used.

3.2 THE INITIAL QUESTIONNAIRE

This questionnaire was distributed to manufacturers on the initial distribution list. This was the first contact most of them had received on this subject. In most cases, all that was known about these firms was that they manufactured filters. What was needed was information concerning potential applications of these filters. Specifically, could they be used as pre-treatment for water purification using reverse osmosis? Therefore, the Initial Questionnaire called for only information that would allow the initial list to be winnowed down. The cover letter for the Initial Questionnaire indicated that there would be a second, more detailed questionnaire sent to selected manufacturers. The Initial Questionnaire and cover letter are at Appendix B.

The intent of question design on the Initial Questionnaire was to enhance the probability of response by making the questions simple and easy to answer. This involved designing the questionnaire to a one page length. The major portion of this questionnaire involved a table which was provided with spaces to be filled in with the requested information. The selection of filter

models was left to the respondent, guided by information in the cover letter. Finally, the respondent was given space to add comments or questions.

3.3 THE FINAL QUESTIONNAIRE

A detailed draft of the Final Questionnaire was developed and provided to the Government for comment. Several improvements were made to the structure of the questionnaire and several items added to the questionnaire based upon the Government's previous experience. The resulting instrument, the Final Questionnaire and cover letter, is at Appendix C.

As in the Initial Questionnaire, great care was taken to design the Final Questionnaire to be as simple as possible to respond with the required information. Another design consideration was to simplify the task of organizing the data when the Final Questionnaire was returned. The Final Questionnaire contained two pages of background information explaining ROWPU characteristics and its operation. A flow chart was included to illustrate the individual functions of the ROWPU.

The questions addressed cartridge filter characteristics, application, performance, safety, handling, storage, and availability. The responses were good, but slow. There were a few firms that responded promptly. Others required follow-up telephone calls to stimulate a response.

The category, "performance", had a high number of not reported. This was because performance varies according to water type. Since ROWPU's are mobile, the selection of a single water type on which to base performance would be difficult. Eight of the

eleven companies returning detailed questionnaires reported that performance ratings could not be given unless a source water was identified.

SECTION 4
DISTRIBUTION AND COLLECTION OF QUESTIONNAIRES

4.1 COMPILATION OF INITIAL DISTRIBUTION LIST

The initial distribution list was a product of the literature search and responses to the CBD announcement. It included 173 cartridge filter manufacturers. The initial distribution list is at Appendix D.

4.2 DISTRIBUTION OF THE PRELIMINARY QUESTIONNAIRE

The Preliminary Questionnaire was sent to all of the firms on the initial distribution list. The cover letter requested a quick response and, in general, responses were received in a timely manner. Sixty-three questionnaires were returned.

4.3 COLLECTION OF PRELIMINARY QUESTIONNAIRES AND REFINEMENT OF DISTRIBUTION LIST

The Preliminary Questionnaires were analyzed and those manufacturers who did not make filters compatible to this investigation were deleted from the list. This determination was made based upon type of material filtered, and the application of the filter. If the filter was made for filtering oil or fuel, or if it was designed for a much larger or smaller application, it was eliminated from consideration. The refined distribution list then consisted of 35 manufacturers whose products might meet or approach the established criteria. The final distribution list is at Appendix D.

4.4 DISTRIBUTION AND COLLECTION OF THE DETAILED QUESTIONNAIRE

The Detailed Questionnaire was sent to the filter manufacturers on the refined distribution list. The cover letter stated that the questions were all linked to evaluation criteria and requested response to each question to assure fair and equitable consideration. A response was requested no later than one month later. Responses began to arrive after a few weeks, and when the deadline arrived, several addressees had not responded. When those firms which had not responded were telephoned, most forwarded their completed questionnaires within two weeks. The final tally was 11 manufacturers returning 13 detailed questionnaires. Commercial Filters Incorporated reported data for three different filters on three detailed questionnaires. The response by 11 manufacturers of 35 queried is considered good.

Those Are:

- Applied Fluid Technology
- Eden Equipment Co.
- WETTEC Inc.
- Osmonics Inc.
- 3M
- Bioken Inc.
- Commercial Filters Inc.
- Delta Pure Inc.
- Strainrite Inc.
- Nuclepore Inc.
- Micron Separations Inc.

SECTION 5
ANALYSIS OF QUESTIONNAIRE RESPONSES

5.1 FINAL QUESTIONNAIRE RESPONSES

The final questionnaire was longer and more detailed than the initial questionnaire. It was designed to collect specific information concerning selected filters for use as a prefilter in ROWPUs. Of the thirteen questionnaires completed, several different methods of filtering were utilized. Eight manufacturers provided information on pleated filters, four manufactured depth filters, and one furnished information on bag filters.

5.2 EVALUATION CRITERIA

Each of the thirteen filters was then evaluated according to its ability to meet or approach the established criteria for performance, behavior, compatibility, reusability, handling, cost, and availability. The detailed evaluation criteria and weights assigned to each criteria are at Appendix E.

Each of these attributes received a weighted value to better evaluate the filters against one another. These figures are estimates which are based on knowledge gained in the cartridge filter study. The criteria and weights were approved by the Government TPOC before being used to evaluate filters.

For each attribute, additional characteristics were further provided. These characteristics also have weighted values in order to evaluate them against different filters.

The detailed questionnaire contained questions which provided answers to the characteristics needed to perform the analysis. The information provided by the manufacturers was compared to operating specifications of the ROWPU provided by the Government TPOC. If the filters met or surpassed the specifications, they were granted the entire value allowed for the specific category. However, if the filter fell short of the expected performance, points were subtracted according to a decision analysis graph developed by SAIC.

The number of points received by the filter was then multiplied by the evaluation weight assigned to each characteristic. When a characteristic was not reported, the percentage rate assigned to that characteristic was subtracted from 100. The number of points the filter received was then divided by the number obtained from subtracting the percentage rate from 100. The number can then be multiplied by the percentage assigned to the category. This process is called normalizing, and it protects against a filter receiving a top score just for returning a fully completed questionnaire.

The candidate filters are analyzed with respect to each of these attributes in the following paragraphs.

5.2.1 Filter Evaluation

5.2.1.1 Performance. The performance attribute consists of the following characteristics: silt density index, nephelometric turbidity units (NTU), absolute micron rating, pressure drop, lifetime of the filter, holding capacity, and leakage. The problem with evaluating these characteristics is that they vary in relation to the source water. Since ROWPUs are mobile, a single water source cannot be identified to test these characteristics; a standard water source is not available. A few of the manufacturers

attempted to answer the performance questions by basing their answers on a defined water source, but they could not be compared with other manufacturers who used a different water source. Because of this problem, the performance category was dropped in the analysis of the filters.

5.2.1.2 Behavior. Questions in the behavior category had a better response rate. This category was supposed to measure how well the filter could hold up to conditions found in ROWPUs. Characteristics in this category included: solids load, flow rate, liquid pressure, temperature, pH range, and viscosity range. Each of these characteristics were assigned a weighted value according to its importance in evaluating the filter. The overall category was also assigned a weighted number to compare it to other categories. In this case, behavior has a weight of 20 percent.

Most of the filters received a high percentage in this category. The ability to handle a flow rate of 30 GPM and a liquid pressure of 100 PSI were two of the most important characteristics. Every filter fit into the temperature range required by the ROWPU, and most filters could handle a pH range between 3 and 11. This led to many similar scores, although there were a few filters that outperformed the rest.

Eden/Exel received a perfect score in this category as did Applied Fluid Technology, 3M, Delta Pure, M.S.I, and Nuclepore. These filters all use a pleated, porous surface as their filtering mechanism.

5.1.2.3 Compatibility. This attribute was designed to measure the ability of the filter to fit in the current housing found in the ROWPU. The characteristics included: fit current housing, compatibility with ROWPU chemicals, ability of filter to be used with potable water, corrosion associated with using the filter, and

seal method used in the filter. Each of these characteristics was given a weighted value as well. The category was given a weight of 20 percent.

This category also had a good number of perfect scores, probably due to the detailed explanation and specifications sent to the manufacturers along with the detailed questionnaire. Manufacturers were able to examine the current operating procedures of the ROWPU and reply with a filter that closely matched the current model. Applied Fluid Technology, Eden/Exel, Osmonics, Commercial Filters, Nuclepore and M.S.I all had perfect scores in this category. These again are the filters that use a pleated design as their filtering mechanism.

5.1.2.4 Reusability. This was a fairly simple attribute to measure. The manufacturers either had a positive response or a negative one. The characteristics contained in this category were: reusable, easy to clean, and time to clean. These characteristics were given weighted numbers to evaluate them and the category was given a weight of 10 percent.

Very few of the manufacturers who replied to the detailed questionnaire claimed to produce a filter that was reusable. The three that did were Eden/Exel, WETTEC, and Bioken. Bioken and WETTEC are not traditional cartridge filters and would require a change in the housing to implement their use. Bioken employs a ultrafiltration (UF) cartridge housing with UF spiral cartridges in its filtering mechanism. WETTEC uses a heavy duty polypropylene housing and 4-1/2 inch pleated filters to filter the source water. These filtering techniques were included as a possible change for the future.

The Eden/Exel is a pleated filter that can be hosed off and reused. The level of degradation for future use is 50 percent. This is significant and may not be recommended, but if compared to permanently shutting down the ROWPU, it is a viable option. Many of the manufacturers of pleated filters reported that reusing their filters was possible, but not recommended. This may mean their degradation is even higher than 50 percent.

5.2.1.5 Handling. This attribute was meant to measure the filter's ability to stand up to the transportation and storage requirements of a filter used in the ROWPU. This category included: shelf life, replacement ease, storage temperature, safety, and transportation durability. These characteristics were given a weighted average, and the category was given a weight of 5 percent.

Most of the filters performed well in this category. Perfect scores were turned in by Applied Fluid Technology, 3M, Commercial Filters and M.S.I. Shelf life was an important characteristic in this category, and Eden/Exel, Commercial Filters, and 3M all reported an indefinite shelf life.

5.1.2.6 Cost Per Unit. Cost was not a major consideration in this investigation, however, no realistic evaluation can completely ignore cost. A few cost factors were considered. The cost of the filter and the number of filters needed for this application were included in this category. This category was given a weight of 5 percent.

Cartridge filters are inexpensive items and in this category a perfect score was given to a filter that cost less than $10. Most of the filters came in under $10.

5.1.2.7 Availability. This category attempted to insure that a filter chosen would be available in sufficient supply for the Army's needs. This category included manufacturer volume and length of time the filter had been on the market. This category was given a weight of 5 percent.

This category contained a question concerning volume manufactured. Some manufacturers did not answer this question because they considered it proprietary information. However, most of these firms appear large enough to keep up with demand for filters from the Army.

5.3 Summary.

The breakdown of categories and characteristics is contained in the following matrix. The percentages assigned to each characteristic are listed along with the total each filter received. The total is reported at the end of the matrix along with an explanation of the matrix itself. There are two totals reported in the matrix. One is the total including "performance" and the other is a normalized total without the "performance" attribute.

EVALUATION MATRIX FOR ROWPU CARTRIDGE FILTERS

Because of the difficulty in evaluating the performance category, the sum of scores were adjusted by leaving out the performance category and normalizing the remaining categories to 100%.

			Applied Fluid Tech			Eden Equipment Co			WETTEC	OSMONICS		3M		BIOKEN	COMMERCIAL FILTERS			DELTA PURE NUC		STRAIN	M.S.I
Characteristic	Spec	Wt	1100	2100	3000	Pleat	Depth	Carbon	Pleat	HYTREX	MP	300	700	UF	POLY	ADVNTGE	XTL/HFT		QMC		
1.PERFORMANCE 35%																					
Silt SDI	<5	20	NR	NR	NR	NR	NR	NR	NR	NR	NR	20	NR	20	NR	NR	NR	NR	20	NR	NR
Nephel NTU	<1	20	NR	NR	NR	NR	NR	NR	NR	NR	NR	0	NR	20	NR	NR	NR	NR	NR	NR	NR
Abs Micron Rate		15	NR	NR	NR	15	NR	NR	10	5	15	15	NR	15	15	15	15	NR	15	?	?
Pressure Drop		15	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Lifetime	>40hr	15	NR	NR	NR	NR	NR	NR	15	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Holding Capac	<5	10	?	NR	NR	?	NR	NR	10	?	NR	NR	NR	?	?	?	?	10	?	?	NR
Leakage		5	NR	NR	NR	NR	NR	NR	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
2. BEHAVIOR 20%																					
Solids Load		20	?	NR	NR	?	NR	NR	?	?	NR	?	NR	?	?	?	?	?	?	?	NR
Flow Rate	30 or 100GPM	20	20	20	20	20	20	0	20	15	10	20	20	20	11	11	11	20	20	20	20
Liquid Pressure	100PSI	20	NR	NR	NR	NR	20	NR	NR	20	13	NR	NR	10	6	6	6	20	20	5	20
Temperature R	32°F-110°F	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
pH Range	3-11	15	15	NR	NR	15	NR	10	5	15	NR	15	NR	15	15	15	15	15	15	15	15
Viscosity Range		10	?	NR	NR	?	NR	NR	?	?	NR	?	NR	?	?	?	?	?	?	?	NR

NR - Not Reported
? - Data difficult to evaluate and compare

EVALUATION MATRIX FOR ROWPU CARTRIDGE FILTERS(Continued)

Characteristic	Spec	Wt	Applied Fluid Tech			Eden Equipment Co			WETTEC	OSMONICS		3M		BIOKEN	COMMERCIAL FILTERS			DELTA	NUC	STRAIN	M.S.I
			1100	2100	3000	Pleat	Depth	Carbon	Pleat	HYTREX	MP	300	700	UF	POLY	ADVNTGE	XTL\HFT		QMC		
3. COMPATAB-TY20%																					
Fit Current Hou	40"x2" 5/8,¾	30	30	30	30	30	30	0	0	30	30	0	0	0	30	30	30	30	30	0	30
ROWPU Chemicals		25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
Potable Water		15	15	NR	NR	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Corrosion Diff		15	NR	NR	NR	NR	NR	NR	15	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Seal Method		15	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
4.REUSABILITY 10%																					
Reusable		40	0	0	0	40	0	0	40	0	0	0	0	40	0	0	0	0	0	0	0
Easy to Clean		30	0	0	0	30	0	0	30	0	0	0	0	30	0	0	0	0	0	0	0
Time to Clean		30	0	0	0	30	0	0	30	0	0	0	0	30	0	0	0	0	0	0	0
5. HANDLING 5%																					
Shelf Life		25	25	NR	NR	25	NR	NR	20	20	NR	25	NR	15	25	25	25	25	15	25	25
Replace Ease		20	20	NR	NR	20	NR	NR	20	20	NR	20	20	20	20	20	20	20	20	20	20
Storage Temp	-35°F-160°F	20	20	NR	NR	17	NR	NR	NR	15	NR	20	NR	13	20	20	20	17	0	10	20
Safety		20	20	NR	NR	20	NR	NR	20	20	NR	20	20	20	20	20	20	20	20	20	20
Transport Cond		15	15	NR	NR	20	NR	NR	15	15	NR	15	NR	15	15	15	15	15	15	15	15

EVALUATION MATRIX FOR ROWPU CARTRIDGE FILTERS(Continued)

Characteristic	Spec	Wt	Applied Fluid Tech			Eden Equipment Co			WETTEC	OSMONICS		3M		BIOKEN	COMMERCIAL FILTERS			DELTA	NUC	STRAIN	M.S.I
			1100	2100	3000	Pleat	Depth	Carbon	Pleat	HYTREX	MP	300	700	UF	POLY	ADVNTGE	XTL/HFT		QMC		
6. COST 5%																					
Filter	<$10	50	NR	NR	NR	50	NR	NR	50	50	NR	50	0	0	50	50	50	NR	NR	50	0
#/Application		50	50	NR	NR	50	NR	NR	50	50	NR	0	NR	50	50	50	50	50	50	50	50
7.AVAILABILITY 5%																					
Manufacture Vol		60	NR	NR	NR	60	NR	NR	60	60	NR	NR	NR	NR	60	60	60	60	60	60	60
Market Time		40	10	NR	NR	40	NR	NR	6	40	NR	2	NR	40	10	10	20	40	40	40	20
NORMALIZED			80%	80%*	80%*	99.6%	80%*	42%*	79.6%	81.5%	75.1%*	62.9%	60.6%*	72.1%	72.1%	72.9%	84.3%	84.3%	82.3%	64%	79.23%
NON-NORMALIZED			80%	80%*	80%*	99.8%	80%*	42%*	76.8%	68%	80.9%*	67.1%	60.6%*	85.1%	81.9%	81.9%	82.4%	89.85%	88.5%	64%	79.23%

* Data obtained from information sent by companies, not completed questionnaires.

? Data reported but difficult to evaluate.

SECTION 6
CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

6.1.1 Filters

The pleated filters performed best in the analysis. Eden/Exel received the highest score with a 99.6 percent as normalized without the "performance" attribute. This was due to its pleated mechanism for filtering and its reusability. The ability of this filter to be reused pushed it past other pleated filters which could not be reused. However, the other pleated filters performed well and should not be eliminated.

Data received from this survey and information obtained in researching cartridge filters clearly show pleated filters to be a more effective prefilter in Reverse Osmosis applications. String wound filters tend to unload trapped particles with any surges in the lines. Dirt is trapped in a string wound filter, and during a back surge will break lose and pass into the membrane. In a study by Harry Sandstedt and Joseph Weisenberger string wound filters showed "leakage, and dumping of some of the captured dust." The study concluded by stating that "there is some question whether this cartridge should be used at pressures greater than 20 psi."

6.2 RECOMMENDATIONS

It is recommended that BELVOIR:

- Convert from the present string wound filament wound cartridge to a pleated cartridge.

- Because of the lack of performance data supplied by the manufacturers, purchase the pleated cartridges listed in this report and test them on the ROWPU. Belvoir would then be able to gather consistent, independent data to evaluate filter perfcrmance.

- Select the best filter based on performance data.

APPENDIX A

STATEMENT OF WORK

MARKET INVESTIGATION AND MATERIAL EVALUATION

OF CARTRIDGE FILTERS

STATEMENT OF WORK AND SERVICES FOR MARKET ANALYSIS AND MATERIEL EVALUATION OF CARTRIDGE FILTERS FOR THE FAMILY OF WATER SUPPLY EQUIPMENT

1. The contractor shall perform the following work and services:

DESCRIPTION OF WORK:

Background: The Logistics Equipment Directorate is responsible for development and assistance during production and fielding of approximately 100 U.S. Army materiel programs, one of which is the Family of Water Supply Equipment, which includes the 600 GPH Reverse Osmosis Water Purification Unit (ROWPU) and the 3,000 GPH ROWPU. The Army is presently using Filterite filament wound, 5 micron (nominal) cartridge filters as its final filtration step in the pretreatment section of the ROWPU. These filters are consumable items which must be replaced once the pressure drop through the filters becomes too great. There may be filters commercially available which have longer life, higher solids removal efficiencies and may even be reusable. Use of these types of new filters may improve the overall effectiveness of the ROWPU pretreatment section. A market investigation of commercially available cartridge filters is necessary to determine the best type of cartridge filter for use in the pre-treatment section of the ROWPUs.

Objective: The objective of this task is to conduct a comprehensive market analysis of commercially available cartridge filters that may be used in the pre-treatment section of the ROWPU. The market analysis will concentrate solely on this item.

Program Approach: The contractor's expertise in system/hardware integration and the materiel acquisition process will be used to conduct the market analysis and materiel evaluation on the cartridge filters available for the ROWPU. This effort will develop an in-depth questionnaire, provide a comprehensive description of the cartridge filters available, and, in conjunction with government technical representatives, conduct an in-depth evaluation of these items resulting in a recommendation of the most promising cartridge filter.

Task I. Literature Search and Concept Review. The Government technical point of contact will conduct a comprehensive review of available literature and previous related studies. This preliminary assessment of literature on cartridge filters which can be used in the pre-treatment section of ROWPUs, will provide the basis for the development of a market analysis questionnaire. The Belvoir Foreign Information Office shall also be queried to provide information on pertinent foreign cartridge filter systems. The resulting information will be provided to the contractor by the Government at the post award conference which shall occur within ten days of task order award. This contractor shall also be briefed by the technical point of contact on the cartridge filters currently used in the ROWPU, associated problems and other pertinent information on ROWPU operations. One complete set of documentation consisting of previous ROWPU reports and the 600 GPH ROWPU operator's manual will be provided as reference material for conduct of this effort. (C.4.2.b)

Task II. Development of a Market Survey Questionnaire. The contractor shall develop, in conjunction with government technical representatives, a market survey questionnaire. The purpose of the questionnaire will be to gather the technical information needed to determine whether the cartridge filter systems in question will satisfy the needs of the U.S. Army's water purification equipment. The contractor shall develop this questionnaire in draft form and submit it to the government for approval. (C.4.2b)

Task III. Distribution of the Questionnaire and Collection of Data. The contractor will develop a distribution list for the market analysis questionnaire in conjunction with the government. The resulting distribution list will be based upon information gathered during the government literature search and as a result of a government Commerce Business Daily (CBD) announcement, which will be developed by the contractor in conjunction with government technical representatives. The government approved list will be used to distribute the questionnaire. The contractor will distribute the questionnaires and coordinate the collection of required information on cartridge filters. The data received in response to the questionnaire will be organized and categorized by the contractor in a logical and easy to use manner. (C.4.2b)

Task IV. Analysis of Data. The contractor will analyze the responses to the questionnaire and, when necessary, will contact the non-respondees and incomplete respondees for follow-up information to permit complete evaluation of their products. The contractor will evaluate all the responses based on requirements and criteria developed in conjunction with the government, and determine which cartridge filters are most promising for use in the pre-treatment section of the ROWPUs in the Family of Water Supply Equipment. A detailed review of the gathered literature shall also be performed. As a minimum, this analysis of the literature will examine and evaluate the following filter characteristics: solids removal efficiency; estimated lifetime; cleanability; ease of replacement; size; cost; and hydraulic behavior (i.e. operating pressure and pressure drop). (C.4.2b)

Task V. Technical Report and Study Gist. The contractor will document results of the above tasks in a Final Technical Report and Study Gist. (C.5)

2. The work shall be in accordance with Section C of the contract and CLIN 0003. Data, CLIN 0004 shall be delivered as set forth on Contract Data Requirements List, DD Form 1423, Sequence Numbers A001, A002, A007, A008 and A009, dated 19 December 1989 and 13 March 1990.

3. CLASSIFICATION: Work on this task order may be classified up to SECRET. If SECRET information is used in the report, it will be contained in a separate classified annex.

4. GOVERNMENT FURNISHED EQUIPMENT: None.

5. The completion date for this task order is 30 October 1990.

6. Deliverables will be shipped to Block 14, DD 1155, ATTN: STRBE-HP, Brad Spitznogle.

APPENDIX B

INITIAL QUESTIONNAIRE

Science Applications International Corporation
An Employee-Owned Company

May 18, 1990

Dear

Science Applications International Corporation is under contract to assist the US Army Belvoir Research, Development and Engineering Center of Fort Belvoir, Virginia, in obtaining information on cartridge filters that can improve the performance of military Reverse Osmosis Water Purification Units (ROWPU). The objective is to determine if cartridge filters are available that can increase effectiveness and efficiency over the current, filament-wound, extended core, 5-micron (nominal) cartridge filter.

Your firm was identified as a manufacturer of cartridge filters or related products. We would like information on your products that can improve filtration performance. These goals include the following: high capture efficiency, product turbidity < 1 NTU, SDI < 5, ability to stop small particles, high contaminant-holding capacity, low pressure drop, long life, ability to be cleaned and reused, ease of replacement, and low cost. Please complete the attached preliminary questionnaire and include any appropriate brochures or data sheets. Information on current research and development that may result in improved cartridge filters would also be appreciated.

We would like your response within three weeks. We will then send a more detailed questionnaire to obtain complete information on the products that have promise for Army use. This preliminary request for information is also being conducted using a Commerce Business Daily Announcement. If you have questions or comments, please do not hesitate to contact the undersigned at (703) 734-5881, or at the address below. Information will only be accepted on a no cost or obligation basis. Proprietary information will be appropriately protected. Thank you for your attention to this matter.

Sincerely,

SCIENCE APPLICATIONS
INTERNATIONAL CORPORATION

Patrick G. Potter
Principal Investigator

Attachments A/S

1710 Goodridge Drive, P.O. Box 1303, McLean, Virginia 22102 (703) 821-4300
Other SAIC Offices: Albuquerque, Boston, Colorado Springs, Dayton, Huntsville, Las Vegas, Los Angeles, Oak Ridge, Orlando, Palo Alto, San Diego, Seattle

CARTRIDGE FILTER
PRELIMINARY QUESTIONNAIRE

1. DOES YOUR FIRM MANUFACTURE CARTRIDGE FILTERS OR RELATED EQUIPMENT? _____ IF YES, PLEASE PROVIDE THE NAME AND TELEPHONE NUMBER OF A PERSON TO CONTACT FOR MORE INFORMATION, THEN CONTINUE BELOW:

_____

2. IF NO, PLEASE DESCRIBE YOUR OTHER PRODUCTS THAT MAY BE APPROPRIATE FOR FUTURE MILITARY WATER TREATMENT ROWPU INVESTIGATIONS, THEN GO TO QUESTION 5:

_____
_____
_____

3. PLEASE DESCRIBE THE APPLICATIONS FOR WHICH YOUR CARTRIDGE FILTERS OR RELATED FILTRATION EQUIPMENT ARE DESIGNED. DO THE APPLICATIONS INCLUDE PRE-TREATMENT FOR WATER PURIFICATION USING REVERSE OSMOSIS?

_____
_____
_____
_____

4. PLEASE LIST THE MODELS/TYPES OF CARTRIDGE FILTERS WHICH ARE APPROPRIATE FOR WATER PURIFICATION (USE ADDITIONAL PAGE IF NEEDED):

TYPE FILTER	FILTER MATERIAL	NOMINAL RATING

5. IS YOUR COMPANY CONDUCTING R&D EFFORTS TO IMPROVE CARTRIDGE FILTERS OR OTHER WATER TREATMENT SUBSYSTEMS WITH APPLICATION TO ARMY ROWPU NEEDS?:

_____
_____
_____
_____

PLEASE RETURN THIS PRELIMINARY SURVEY FORM AND ANY APPROPRIATE DATA TO:

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
ATTN: Michael Clark (T1-7-2)
1710 GOODRIDGE DRIVE
MCLEAN, VIRGINIA 22102

THANK YOU FOR YOUR INPUT.

APPENDIX C

FINAL QUESTIONNAIRE

Science Applications International Corporation
An Employee Owned Company

2 July 1990

Dear

Science Applications International Corporation is under contract to assist the Fuel and Water Supply Division of the US Army Belvoir Research, Development and Engineering Center (BELVOIR) in a survey and evaluation of cartridge filters or similar items that offer improved performance over current products. BELVOIR seeks to determine the best type of cartridge filter for use in the pre-treatment section of Reverse Osmosis Water Purification Units (ROWPU).

Currently the Army uses a consumable filter that must be replaced once the pressure drop through the filter becomes too great. The Army hopes to find a commercially available filter which has a longer life, a higher solids removal efficiency, compatibility with Army ROWPU materials and chemicals, and may possibly be reused after cleaning.

Please find enclosed Background Information on Army Cartridge Filters (ATT. 1) and a Detailed Technical Questionnaire (ATT. 2) concerning Cartridge Filters manufactured by your firm. This questionnaire is a follow up to information that you provided us recently. The questionnaire incorporates information on the configuration and other aspects of the cartridge filter or similar item that are important for Army requirements. A questionnaire should be completed for each model or series of filters that meet Army needs. Proprietary information will be protected. Please respond to each question, and return the information by August 10, 1990 to:

Science Applications International Corporation
ATTN: Michael Clark (T1-7-2)
1710 Goodridge Drive
McLean, VA 22102

If you have questions or comments, please contact the undersigned at (703) 821-4347 or Michael Clark at (703) 556-7222. Thank you for your assistance.

Sincerely,

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

John Daugherty
Principal Investigator

ATTACHMENTS A/S

1710 Goodridge Drive, P.O. Box 1303, McLean, Virginia 22102 (703) 821 4300

Other SAIC Offices: Albuquerque, Boston, Colorado Springs, Dayton, Huntsville, Las Vegas, Los Angeles, Oak Ridge, Orlando, Palo Alto, San Diego, Seattle

ATTACHMENT 1 - BACKGROUND INFORMATION

The US Army Reverse Osmosis Water Purification Unit (ROWPU) provides potable water for drinking, washing, culinary, bathing, laundering, and dehydrated-food-reconstitution purposes under military field conditions. Figure 1 depicts the 600 gallon per hour (GPH) trailer mounted ROWPU; a 3,000 GPH ROWPU is also available that is truck mounted. The ROWPU uses the process shown in Figure 2, on the following page, to produce potable water. Raw water is injected with polymer and Sodium Hex before flowing through a media filter and then through the cartridge filter. The Army ROWPU must be capable of world-wide use including the following types of raw water: fresh, brackish, and sea.

Current specifications for the ROWPU cartridge filter housing and cartridge filters should be used as general guidelines for the survey, though modifications will be considered if improved performance will result. The cartridge filter housing is 56 in. high X 10.75 in. in diameter. The water inlet is 15 in. above the base, and the outlet is 6 in. lower on the opposite side of the tank. The design pressure is 125 PSIG with a flow rate of about 35 gallons per minute. The pH range is normally about 3 to 11. Operating temperature is -20° to 110° F and storage temperature is -35° to 160° F. All external parts of the tank are of fiberglass reinforced plastic or stainless steel. All internal parts are plastic or rubber coated. The tank holds eight cartridge filters. Internal design of the tank provides for self-alignment of the cartridge filter tubes and retention of filter tube top seat plates.

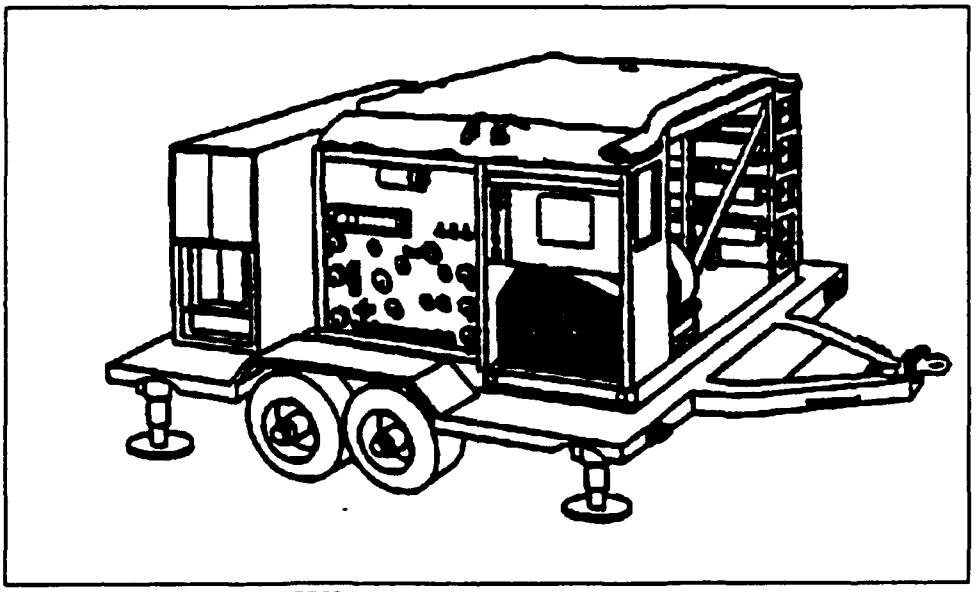


Figure 1 - ARMY 600 GPH ROWPU

The filter cartridges are 40 in. long and either 2.62 or 2.75 in. OD. The core is 1.0 in. OD and extends the entire length of the cartridge filter with a 1.25 in. extension at the bottom. Material for the filter, core, and core extender is polypropylene. The density of the polypropylene will permit 5 micron nominal removal rating. The filter is integrally (usually circumferentially) wound.

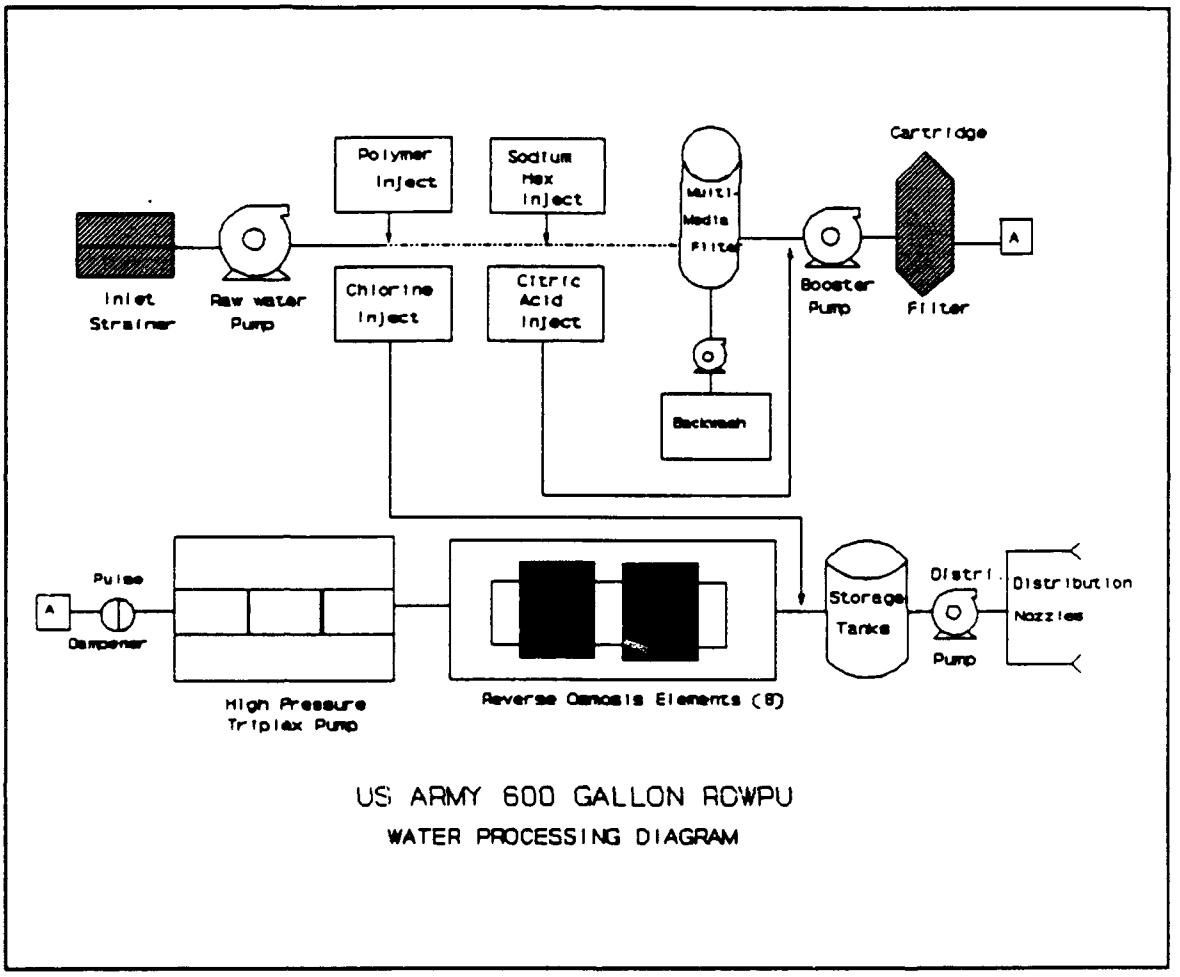


Figure 2 - ARMY ROWPU FLOW CHART

DETAILED QUESTIONNAIRE
CARTRIDGE FILTER PRODUCT

A. PRODUCT CHARACTERISTICS:

1. Dimensions of this cartridge filter (length by diameter) in inches: _____ (600 GPH ROWPU uses 2.62" or 2.75" diameter by 40" long extended core filters) Will the filter fit the current cartridge filter housing: _____ If not, describe the type of housing and seating mechanism required: _____

2. Describe filtering mechanism (surface or depth) and type filter (such as wound, packed, stacked disk, preformed, pleated, membrane, cross-flow, or other): _____

3. What materials are used in the manufacturing of the cartridge filter: _____

4. Is the cartridge filter compatible with the process and materials used in the Army ROWPU (see background description for specific materials and chemicals that are used): _____

B. APPLICATION DATA:

1. What is the maximum acceptable flow rate and liquid pressure through the cartridge filter (The pretreatment sections operate at 100 PSI; the 600 GPH flow is 30 GPM; the 3,000 GPH flow is 100 GPM): _____

2. What is the temperature range that the cartridge filter can operate under: _____

3. What is the range of viscosity acceptable to the cartridge filter: _____

4. How many filters are necessary for the ROWPU: _____

5. What is the maximum recommended solids load (in ppm or mg/l) that the cartridge filter can accept: _____

6. Can the cartridge filter process the types of materials usually found in raw water such as colloidal, suspended solids, and organic foulants (also can it be used for Nuclear, Biological and Chemical contamination particles?):

7. What is the acceptable pH range for the cartridge filter (Army ROWPU pH range is normally about 3 to 11): _____

C. PERFORMANCE CHARACTERISTICS:

1. What is the absolute particle capture micron rating of the cartridge filter: _____ Describe the technique and conditions under which this rating was determined. _____

2. What is the nominal micron rating of the cartridge filter: _____ Describe the technique and conditions under which this rating was determined.

3. Describe the expected quality of water exiting the filter in terms of Silt Density Index, and turbidity in terms of nephelometric turbidity units (NTU). (specify by type of input water):

4. Is a removal versus particle curve available for the filter? _____

5. What is the solids holding capacity of the filter? _____

6. What is the pressure drop over time by type of water:

7. Estimated lifetime of filter (specify by type of water):

8. Can the filter be cleaned and reused:
If so, what is the level of degradation for future use:

D. SAFETY, HANDLING, AND STORAGE:

1. What safety hazards or considerations are associated with use or storage of the cartridge filter:

2. What approvals does the cartridge filter have for use with potable water (please specify the agencies):

3. What is the temperature range for use of the cartridge filter:
For storage:

4. What is the shelf life of the cartridge filter under ideal storage conditions:
Is shelf life adversely impacted by conditions such as humidity, freeze-thaw cycles, sunlight, high or low temperatures, or other:

5. Do transport conditions, such as shock, vibration, or other, adversely impact the capabilities of the cartridge filter (please specify):

6. What are the procedures for replacing the cartridge filter (also for checking its condition, cleaning and reusing (if applicable), and other actions) (please attach instructions or manuals if desired):

7. If the cartridge filter is reusable, what is the recommended replacement interval: _____

_____

_____

E. AVAILABILITY

1. How long has this cartridge filter been commercially available on the market: _____

_____

2. What volume is currently being manufactured for this particular cartridge filter: _____

_____

_____

3. What is the cost of this cartridge filter per unit, or in lots (100 or 1,000 unit lots if known): _____

_____

F. OTHER COMMENTS OR DATA OF INTEREST

_____

_____

_____

_____

CORPORATE INFORMATION:

Name: _____
Address: _____
_____
_____
Point of Contact: _____
Phone #: _____
Fax #: _____

Note: Filter drawings and specification sheets are welcome.

Please return this survey by 10 September 1990 to:

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
ATTN: Michael Clark (T1-7-2)
1710 Goodridge Drive
McLean, Virginia 22102

Thank you for your help.

APPENDIX D

DISTRIBUTION LIST FOR INITIAL AND FINAL QUESTIONNAIRES

ADDRESS OF FIRMS SENT INITIAL QUESTIONNAIRE	RESPONSE	2ND MAILING	RETURNED	QUERY
Advanced Filtration Technology 2424-T Bates Ave. Concord, CA 94520	NOT RETURNED	NO		
Airguard Industries, Inc. 3807 Bishop Lane P.O Box 32578 Louisville, KY 40232	NEGATIVE	NO		
Allied-Signal Inc. Fram Canada Inc. 305 Romeo Street P.O Box 550 Stratford, Ontario CN N5A6VA	NEGATIVE	NO		
Allied Witan Co. 13805 Progress Pky. Cleveland, OH 44133	NOT RETURNED	NO		
Alsop Engineering Company P.O Box 3427 Kingston, NY 12401	NOT RETURNED	NO		
Aluminum Filter Company 1000 Cindy Lane P.O Drawer 1317 Carpinteria, CA 93013	NEGATIVE	NO		
American Air Filter An Allis-Chalmers Co. P.O Box 35690 Louisville, KY 40232	POSITIVE	YES		
American Filtrona Co. P.O Box 34668 Richmond, VA 23234 (804) 275-2631 R.M Kaufelt	POSITIVE	YES		
Ametex Plymouth Products Division 502 Indiana Ave. Sheboygan, WI 53081 (800) 222-7558 Kurt Kaiser	POSITIVE	YES		YES 9/4/90 NEGATIVE
Anderson Industrial Products, Inc. 597 Deming Rd. Berlin, CT 06037	NOT RETURNED	NO		

ADDRESS OF FIRMS SENT INITIAL QUESTIONNAIRE	RESPONSE	2ND MAILING	RETURNED	QUERY
Applied Membranes, Inc. 542 S. Pacific St. St. Marcos, CA 92069	NEGATIVE	NO		
Aqua-Flo, Inc. 6244 Frankford Ave. Baltimore, MD 21206	NOT RETURNED	NO		
Aqua Pure Systems, Inc. P.O Box 20856-T San Jose, CA 95160	NOT RETURNED	NO		
Aqua-Tec Filter Co. 12410 Clarke Ave. Dept. FS Santa Fe Springs, CA 90670	NOT RETURNED	NO		
Aqualogic, Inc. 30 Devine St. N. Haven, CT 06473	NOT RETURNED	NO		
Aquaman, Inc. 2568-T Turquoise Crl. Newbury Park, CA 91319	NOT RETURNED	NO		
Astro Met Associates, Inc. 9974-U Springfield Pike Cincinnati, OH 45215	NEGATIVE	NO		
Atkomatic Valve Co., Inc. 141 S. Sherman Dr. Indianapolis, IN 46201	NEGATIVE	NO		
Avery Filter Co., Inc. 99 Kinderkamack Rd. Dept. T/R Westwood, NJ 07675	NOT RETURNED	NO		
Balston Filter Products 703 Massachusetts Ave. Box C Lexington, MA 02173-9910 (800) 343-4048 Ted Silva	POSITIVE	YES		
Beverlin Manufacturing Corp. 5519 Raleigh Dr. S.E Grand Rapids, MI 49512 (616) 949-5990 Vernon Olson	POSITIVE	YES		YES 7/23/90 NEGATIVE
Bioken Separations, Inc. 50 Kerry Place Norwood, MA 02062 (800) 367-6805 Robert Cross	POSITIVE	Yes	YES POSITIVE	Yes 8/15/90 POSITIVE

ADDRESS OF FIRMS SENT INITIAL QUESTIONNAIRE	RESPONSE	2ND MAILING	RETURNED	QUERY
Bird Environmental Systems, Inc. 100 Neponset St. South Wapole, MA 02071	NOT RETURNED	NO		
Brunswick Defense 3333 Harbor Blvd. Costa Mesa, CA 92628 Harry Buehrle (714) 546-8030 x6280 Fred Afshar x6139 (Engr)	POSITIVE	YES		YES 7/31/90 POSITIVE
Calfrex, Inc. P.O Box 429 Southport, CT 06490	NOT RETURNED	NO		
Cambridge Filter Corp. P.O Box 4906 Syracuse, NY 13221-4906	NOT RETURNED	NO		
Carter & Co. 137 E. Calhoun St. Memphis, TN 38103	NOT RETURNED	NO		
Cellulo Co. 27-T North Ave. E. Cranford, NJ 07016	NOT RETURNED	NO		
Certech, Inc. One Park Place, W. Wood-Ridge, NJ 07075	NOT RETURNED	NO		
Chicago Spence Tool & Rubber Co. 10101 Pacific Ave. P.O Box 250 Franklin Park, IL 60131	NOT RETURNED	NO		
Clean Water Systems 4959 Dunman Ave. Woodland Hills, CA 91364	NOT RETURNED	NO		
Cochrane Environmental Systems 800 Third Ave. King of Prussia, PA 19406	NOT RETURNED	NO		
Com-Pac Filtration, Inc. 825 N. Myrtle Ave. P.O Box 40071 Jacksonville, FL 32203	NOT RETURNED	NO		

ADDRESS OF FIRMS SENT INITIAL QUESTIONNAIRE	RESPONSE	2ND MAILING	RETURNED	QUERY
Combustion Engineering, Inc. 900 Long Ridge Rd. Stamford, CT 06902	NOT RETURNED	NO		
Consler Corp. Applied Fluid Purification Div 290 W. Main St. Honeoye Falls, NY 14472 (716) 624-1330 Thomas Dickson	POSITIVE	YES	YES POSITIVE	
Continental Water Systems Corp. P.O Box 40369 San Antonio, TX 78229-1369 (800) 426-3426 David Reid	POSITIVE	YES		
Corrick International P.O Box 66931 230-H Mt. Scotts Valley, CA 95067	NOT RETURNED	NO		
C.P.C c/o Ad Track P.O Box 3064 Cedar Rapids, IA 52406-3064	NEGATIVE	NO		
Crown Engineering Corp. Squankum-Yellow Brook Rd. P.O Box 846-T Farmingdale, NJ 07727	NOT RETURNED	NO		
Cuno, Inc. 400 Research Parkway Meriden, CT 06450	NOT RETURNED	NO		
D.C Filter & Chemical, Inc. 1519 Fifth Street Sandusky, OH 44870	NOT RETURNED	NO		
Delta Pure Filtration Corp. 305 S. Richardson Rd. Hanover Industrial Park Ashland, VA 23005 (804) 798-2888 Joseph G. Yack	POSITIVE	YES	YES POSITIVE	
Desalination Systems, Inc. 1238 A Simpson Way Escondido, CA 92025	NOT RETURNED	NO		

ADDRESS OF FIRMS SENT INITIAL QUESTIONNAIRE	RESPONSE	2ND MAILING	RETURNED	QUERY
Donaldson Co., Inc. Box 1229-A Minneapolis, MN 55440 (612) 887-3494 Ric Canepa	POSITIVE	YES		
Ecowater Systems Com. Products Div. P.O Box 64420 St. Paul, MN 55164	NOT RETURNED	NO		
Eden Equipment Co. 17712-A Gothard Street Huntington Beach, CA 92647 (714) 842-8181 Clark Meacham	POSITIVE	YES	YES POSITIVE	
Eimco Process Equipment Co. Box 300 Salt Lake, UT 84110	NOT RETURNED	NO		
Ensign-Bickford Industries, Inc. 630-T Hopmeadow St. Simsbury, CT 06070	NOT RETURNED	NO		
Envirogenics Systems Co. 9255 Telstar Ave. EL Monte, CA 91731	NOT RETURNED	NO		
Facet Quantek, Inc. P.O Box 50096 Tulsa, OK 74150 (918) 834-2929 Charles Lindsey	POSITIVE	YES		YES 7/15/90 NEGATIVE
Fairey Industrial Ceramics Filleybrooks, Stone, Staffs ST15 OPU England 785-813241 Malcolm Fraser	POSITIVE	YES		
Fastek-A Kodak Co. 7120 Henry Clay Blvd. Liverpool, NY 13088	NOT RETURNED	NO		
Fibredyne, Inc. 47 Crosby Road Dover, NH 03820	NEGATIVE	NO		
FilmTec Corp. 7200 Ohms Lane Station T Minneapolis, MN 55440	NOT RETURNED	NO		

ADDRESS OF FIRMS SENT INITIAL QUESTIONNAIRE	RESPONSE	2ND MAILING	RETURNED	QUERY
Filter Pump Industries Div of Penguin 7932 Ajay Dr. Sun Valley, CA 91352	NOT RETURNED	NO		
Filter Specialists, Inc. 100 Anchor Rd. P.O Box 735-T Michigan City, IN 46360	NOT RETURNED	NO		
Filter Supply Co. 1210-T No. Knollwood Crl. Anaheim, CA 92801-1385	NOT RETURNED	NO		
Filtercor, Inc. 7932 Ajay Dr. Sun Valley, CA 91352	NOT RETURNED	NO		
Filterite 2033 Greenspring Dr. Timonium, MD 21093	NOT RETURNED	NO		
Filtra Corp. 104-T Wagaraw Rd. Hawthorene, NJ 07507	NOT RETURNED	NO		
Filtrine Mfg. Co. 10 Main St. Harrisville, NH 03450	NOT RETURNED	NO		
Flex-Kleen, Research-Cottrell One Northwestern Center 165 N. Canal St, Ste.1040 Chicago, IL 60606	NOT RETURNED	NO		
Flexon, Inc. 2615 Wolcott Ferndale, MI 48220	NEGATIVE	NO		
Flomatic Corp. Box 100 N Hoosick, NY 12133	NOT RETURNED	NO		
Florida Filters, Inc. P.O Box 370985 4th Ave. Miami, FL 33137	NOT RETURNED	NO		
Flow Ezy Filters, Inc. P.O Drawer 1749-T Ann Arbor, MI 48106	NOT RETURNED	NO		

ADDRESS OF FIRMS SENT INITIAL QUESTIONNAIRE	RESPONSE	2ND MAILING	RETURNED	QUERY
Fluid Dynamics 2000 Brunswick Lane Newark, DE 32720	NOT RETURNED	NO		
Fluid Dynamics Brunswick Tecnetics 2000 Brunswick LN Deland, FL 32724	NOT RETURNED	NO		
Fluid Systems, Inc. 7339 Montgomery Box 36307 Cinncinnati, OH 45236	NOT RETURNED	NO		
Foamade Industries 2550 Auburn Ct. Auburn Heights, MI 48057	NOT RETURNED	NO		
Gelber Pumps, Inc. 3721 W. Morse Ave. Lincolnwood, IL 60645 (708) 673-5800 Brent Roland	POSITIVE	YES		
Gelman Sciences 600 South Wagner Rd. Ann Arbor, MI 48106-1448	NOT RETURNED	NO		
General Ecology, Inc. 151 Sheree Blvd. Lionville, PA 19353 (215) 363-7900 Richard Williams	POSITIVE	YES		
Geotech Environmental, Inc. 1441 W. 46th Ave. #17 Denver, CO 80211 (303) 433-7101 Jerry Popiel	POSITIVE	YES		
Hankison Div., Hansen Inc. 1000 Philadelphia St. Canonsburg, PA 15317	NEGATIVE	NO		
Harmsco Filters John Faw Sales 1120 Chestnut Mountain Dr. Vinton, VA 24179 (703) 890-6341 Diane Faw	POSITIVE	YES	YES NEGATIVE	
Harmsco, Inc. P.O Box 14066-T North Palm Beach, FL 33408 1-800-327-3248 Hank Harms	POSITIVE	YES		

ADDRESS OF FIRMS SENT INITIAL QUESTIONNAIRE	RESPONSE	2ND MAILING	RETURNED	QUERY
Hefco Corp. 375-T South St. Eatontown, NJ 07724	NOT RETURNED	NO		
Hoffman Air & Filter Systems P.O Box 548 East Syracuse, NY 13057	NOT RETURNED	NO		
Hoke, Inc. 1 Tenakill PK Cresskill, NJ 07626	NEGATIVE	NO		
Industrial Filters Co. 9-T Industrial Rd. Fairfield, NJ 07006	NOT RETURNED	NO		
ITW Deltar Div, Illinois Tool Works, Inc. 21553 S. Harlem Frankfort, IL 60423	NOT RETURNED	NO		
Kahn & Company, Inc. Goff & Wells Rd. Wethersfield, CT 06109	NEGATIVE	NO		
Katadyne 3020 North Scottsdale Scottsdale, AZ 85251	NOT RETURNED	NO		
Kaydon Corp. 1571 Forrest Ave. Lagrange, GA 30240	NOT RETURNED	NO		
Kent Meters, Inc. P.O Box 1852 Ocala, FL 32678	NEGATIVE	NO		
King Engineering Corp. P.O Box 1228-T Ann Arbor, MI 48106	NOT RETURNED	NO		
Koch Membrane Systems, Inc. 850 Main St. Wilmington, MA 01887	NOT RETURNED	NO		
Komline Sanderson Eng Corp. 12 Holland Ave. Peapack, NJ 07977	NOT RETURNED	NO		
Lamports Filter Media, Inc. 2301 Hamilton Ave. Cleveland, OH 44114	NOT RETURNED	NO		

ADDRESS OF FIRMS SENT INITIAL QUESTIONNAIRE	RESPONSE	2ND MAILING	RETURNED	QUERY
Laubenstein Mfg, Co. 419 So. Hoffman Blvd. Ashland, PA 17921	NOT RETURNED	NO		
Marshall Technical Industries Rte. 4 Box 115 Guntersville, AL 35976	NOT RETURNED	NO		
Medro Systems, Inc. 416 E. Industrial Blvd. McKinney, TX 75069	NOT RETURNED	NO		
Meissner Filtration Products 3750 Cahasset St. Burbank, CA 91505	NOT RETURNED	NO		
Melrath Gasket 30th and Hunting Park Ave. P.O Box 9830 Philadelphia, PA 19140	NOT RETURNED	NO		
Memtek Corp. 28 Cook St. Billerica, MA 01821	NOT RETURNED	NO		
Met Pro Corp. Keystone Filter Div. 2385 N. Penn Rd. Hatfield, PA 19440 (800) 822-1963 Sonja Haggert	POSITIVE	YES		YES POSITIVE 8/29/90
Micro Filtration Systems 6800 Sierra Ct. Dublin, CA 94568	NOT RETURNED	NO		
Micron Separations, Inc. 135 Flanders Rd. P.O Box 1046 Plymouth, MA 01581 (800) 444-8212 John Aldrich	POSITIVE	YES	YES POSITIVE	
Millipore Corp. 80 Ashby RD. Bedford, MA 01730	NOT RETURNED	NO		
Mott Metallurgical Corp. Farmington Industrial Park Farmington, CT 06032	NEGATIVE	NO		
MSC Industrial Supply Co. 151 Sunnyside Blvd. Plainview, NY 11803	NOT RETURNED	NO		

ADDRESS OF FIRMS SENT INITIAL QUESTIONNAIRE	RESPONSE	2ND MAILING	RETURNED	QUERY
NAFCO 200 West Shore Boulevard P.O Box 30 Newark, NY 14513	NOT RETURNED	NO		
National Filtration Corp. Box 159 Star City, AR 71667	NOT RETURNED	NO		
Newmet Krebsoge, Inc. U.S Rt.6 & Burr Rd. P.O Box 68 Terryville, CT 06786 (203) 283-6203 Jim Bradley	POSITIVE	YES		
Norton Performance Plastics 150 Dey Rd. Wayne, NJ 07470	NOT RETURNED	NO		
Nowata Filtration Div. Box 678-T Nowata, OK 74048	NOT RETURNED	NO		
Nuclepore Corp. 7035 Commerce Crl. Pleasanton, CA 94566-3294 1 (800) 882-7711 Jill Reid	POSITIVE	YES	YES POSITIVE	
Osmonics Inc., Hytex Division 5951 Clearwater Drive Minnetonka, MN 55343 (612) 933-2277 Greg Hanson	POSITIVE	YES	YES POSITIVE	
Pacific Sintered Metals Co. 14010 S. Avalon Blvd. Los Angeles, CA 90061	POSITIVE	YES		
Pall Process Filtration Corp. 2200 Northern Blvd. East Hills, NY 11548-1289	NOT RETURNED	NO		
Parker Filter Division 16810 Fulton County Road Metamora, OH 43540	NEGATIVE	NO		
Parker Hannifin Corp. Commercial Filters Div. P.O Box 1300 Lebanon, IN 46052-3006 (317) 482-8309 Harold Byrd	POSITIVE	YES	YES POSITIVE	YES 8/9/90 POSITIVE

ADDRESS OF FIRMS SENT INITIAL QUESTIONNAIRE	RESPONSE	2ND MAILING	RETURNED	QUERY
Permutit Co., Inc. E. 49 Midland Ave. Paramus, NJ 07652	NOT RETURNED	NO		
Pittsfield Products, Inc. P.O Box 1027 Ann Arbor, MI 48106	NOT RETURNED	NO		
Pontiac Plastics 4260 Gedding Rd. Auburn Hills, MI 48055	NOT RETURNED	NO		
Porex Technologies 500 Bohaonon St. Fairburn, GA 30213	NOT RETURNED	NO		
Porous Media Corp. 3727 N. Dulap Ave. St. Paul, MN 55112 (612) 481-1601 Michael Spearman	POSITIVE	YES		
Powercraft Corp. 750 Hayne St. Spartanburg, SC 29301	NOT RETURNED	NO		
Pro-Flo Products, Inc. 29 Ryder Rd. Wayne, NJ 07470 (201) 956-1057	POSITIVE	YES		
Prominent Fluid Controls, Inc. 1005 Parkway View Dr. Pittsburg, PA 15205	NOT RETURNED	NO		
PTI Technologies, Inc. 2323-T Teller Rd. Newbury Park, CA 91319	NOT RETURNED	NO		
Recon Systems, Inc. Rte. 202 North P.O Box 460 Three Bridges, NJ 08887	NOT RETURNED	NO		
Refill Filter Co., Inc. P.O Drawer 1220-T Perth Amboy, NJ 08862	NOT RETURNED	NO		
Refraction Corp. 5750 Stuart Ave. P.O Box 229 Newark, NY 14513	NOT RETURNED	NO		

ADDRESS OF FIRMS SENT INITIAL QUESTIONNAIRE	RESPONSE	2ND MAILING	RETURNED	QUERY
Roberts Filter Manufacturing Co. 214 N.E 83rd. St. Vancouver, WA 98665	NOT RETURNED	NO		
Ronningen Petter 9151 Shaver Rd. Box 188 Portage, MI 49081 (616) 323-1313 Mark R. Smith	POSITIVE	YES		
Rosedale Products, Inc. P.O Box 1085 AnnArbor, MI 48106	NOT RETURNED	NO		
Sartorius Filters, Inc. 30940-T San Clemente, CA 92672	NOT RETURNED	NO		
Schneider, J.R, Co., Inc. 849-T Jackson St. Benicia, CA 94510	NEGATIVE	NO		
Serck Baker, Inc. 5352 Research Dr. Huntington Beach, CA 92649	NOT RETURNED	NO		
Serfilco Ltd. 1234 Depot St. Glenview, IL 60025	NOT RETURNED	NO		
Sethco Division 70 Arkay Drive P.O Box 12128 Hauppauge, NY 11788-3773 (516) 435-0530 Mark Betchaver	POSITIVE	YES		YES 8/29/90 NEGATIVE
Shelco Filtes Div. 37 Grassmere Ave. Dept. A West Hartford, CT 06110 (203) 289-0182 Robert LeConche	POSITIVE	YES		
Solberg Mfg., Inc. 1151-T W. Ardmore Ave. Itasca, IL 60143	NEGATIVE	NO		
SSI Technologies, Inc. 3330 Palmer Dr. P.O Box 5002 Janesville, WI 53547	NEGATIVE	NO		

ADDRESS OF FIRMS SENT INITIAL QUESTIONNAIRE	RESPONSE	2ND MAILING	RETURNED	QUERY
St. Marys Carbon Co. Powder Metallurgy Div. P.O Box 427 St. Marys, PA 15857	NOT RETURNED	NO		
Sta-Rite Water Treatment Group 1875 Dewey Ave. P.O Box 983 Benton Harbor, MI 49022	NOT RETURNED	NO		
Stephen King, Industrial Filtration P.O Box 637 Rocky Mount, VA 24151 (703) 483-9230 Stephen King	POSITIVE	YES	YES NEGATIVE	
Strainrite, Inc. 17 Foss Rd. Foss Industrial Park Lewiston, ME 04240 (207) 777-3100 John Lapoint III	POSITIVE	YES	YES POSITIVE	
Summit Filter Corp. 235 Broad St. Summit, NJ 07006	NEGATIVE	NO		
Summit Scientific Corp. 31 Dwight Place Fairfield, NJ 07006 (201) 227-6190 Arthur Kaye	POSITIVE	YES		
Target Corp. 2 Wacker Park Dr. North Chicago, IL 60064-3703 Tom Oxley	NOT RETURNED	NO		
Tate Engineering, Inc., Commercial filters 601 W. West St. Baltimore, MD 21230	NOT RETURNED	NO		
Techfab, Inc. 205-A Dunn Ave. Piscataway, NJ 08854	NOT RETURNED	NO		
Techniweave, Inc. P.O Box 6314 Rochester, NH 03867 (603) 335-2115 Gary Williams	POSITIVE	YES	SENT NEGATIVE LETTER	YES 8/15/90 NEGATIVE

ADDRESS OF FIRMS SENT INITIAL QUESTIONNAIRE	RESPONSE	2ND MAILING	RETURNED	QUERY
The Beswick Corp. 3230 1-B Stephenson Hwy. Madison Heights, MI 48071	NEGATIVE	NO		
The Hilliard Corporation 102 W. Fourth Street Elmira, NY 14902	NOT RETURNED	NO		
Thermet Krebsoge, Inc. 1 Cape Ann Industrial Park Gloucester, MA 01930	NOT RETURNED	NO		
Thomas Scientific 99 High Hill Rd. at I-295 Swedesboro, NJ 08085-0099	NOT RETURNED	NO		
3M General Offices 3M Center St. Paul, MN 55144-1000 1-800-648-3550 Nancy Elstad	POSITIVE	YES	YES POSITIVE	YES 7/26/90 POSITIVE
Total Plastics, Inc. 5270 Winn Rd. Kalamazoo, MI 49001	NEGATIVE	NO		
Tri-Screen, Inc. P.O Box 864-T Baldwin Park, CA 91706	NOT RETURNED	NO		
UF Strainrite 17 Foss Road Foss Industrial Park Lewiston, ME 04240	POSITIVE	YES		
UT Strainrite 190 Wallace St. New Haven, CT 06450	NOT RETURNED	NO		
Vanton Pump & Engine Corp. 201 Sweetland Ave. Hillsdale, NJ 07205	NOT RETURNED	NO		
Vaponics, Inc. 200 Cordage Park Plymouth, MA 02360	NOT RETURNED	NO		
Velcon Filters 1750 Rogers Ave. San Jose, CA 95112	NEGATIVE	NO		

ADDRESS OF FIRMS SENT INITIAL QUESTIONNAIRE	RESPONSE	2ND MAILING	RETURNED	QUERY
Vickers, Inc. A Trinova Co. 5353 Highland Drive Jackson, Mississippi 39206	NEGATIVE	NO		
Warrender Fluid Services, Inc. 3685 Commercial Ave. Northbrook, IL 60062	NOT RETURNED	NO		
Water Equipment Technologies, Inc. 832-T Pike Rd. West Palm Beach, FL 33411 (407) 684-6300 Ronald Jaworski	POSITIVE	YES	YES POSITIVE	
Wayne Products, Inc. Box 1009-C Berwyn, PA 19312	NOT RETURNED	NO		
Wayne Wire Cloth Products, Inc. 6735 Telegraph Rd. Suite 120 Birmingham, MI 48010	NEGATIVE	NO		
Web Dynamics P.O Box 268-TR Flanders, NJ 07836	NOT RETURNED	NO		
Westates Carbon 1919 Raymond Ave. Los Angeles, CA 90007	NOT RETURNED	NO		
World Water Systems, Inc. 130-A E. Dyer Rd. Dept. W Santa Ana, CA 92707	NOT RETURNED	NO		
Yankee Wire Cloth Products, Inc. 22nd. Street P.O Drawer 58 West Lafayette, OH 43845	NOT RETURNED	NO		
Zenon Corp. 13 Estates Dr. Sussex, NJ 07461 Dr. Hugh Fleming	NOT RETURNED	NO		

APPENDIX E

EVALUATION CRITERIA

WEIGHTS FACTORS

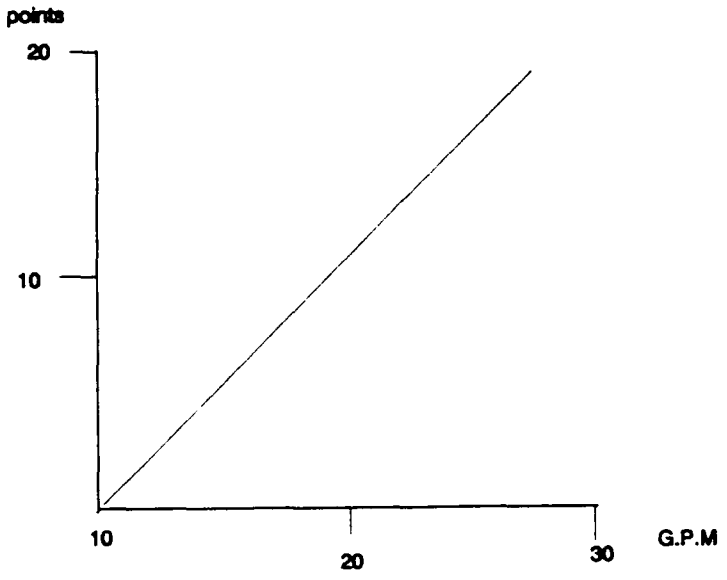
The following weight factors attempt to assign a percentage to characteristics important in evaluating cartridge filters for use in Army Rowpu's. These figures are estimates, and based on knowledge gained in the Cartridge Filter study.

1. PERFORMANCE		35%
Silt Density Index (SDI) <5	20%	
Nephelometric Turbidity Units (NTU) <1	20%	
Absolute Micron Rating	15%	
Pressure Drop Over Time	15%	
Estimated Lifetime of Filter > 40 hours	15%	
Solids Holding Capacity < 5 microns	10%	
Any Chemical Leakage Out of Filter	5%	
	100%	
2. BEHAVIOR		20%
Maximum Recommended Solids Load	20%	
Flow Rate (30 GPM or 100 GPM)	20%	
Liquid Pressure (100 PSI)	20%	
Temperature Range (32° to 110° F)	15%	
Acceptable PH Range (3 to 11)	15%	
Range of Viscosity	10%	
	100%	

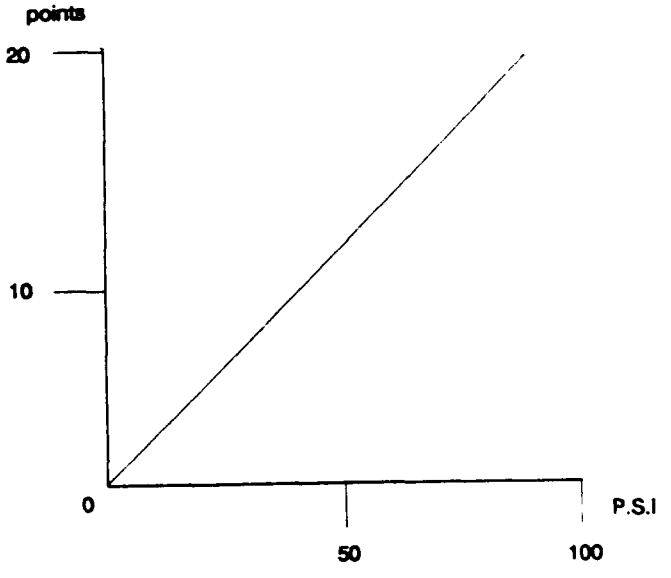
3. COMPATIBILITY		20%
Fit Current Housing (40" x 2 5/8" or 2 3/4")	30%	
Ability to be used with Chemicals in ROWPU	25%	
Compatible with potable water	15%	
Problems with Corrosion if Different Housing Used	15%	
Type of Sealing Method Used	15%	
	100%	
4. REUSABILITY		10%
Is the Filter Reusable	40%	
How Easy is it to Clean	30%	
How Long to Clean	30%	
	100%	
5. HANDLING		5%
Shelf Life	25%	
Easy to Replace	20%	
Temperature Range for Storage (-35° to 160° F)	20%	
Safety Hazards Associated with Filter Usage and/or Storage	20%	
Transport Conditions Effect Filter	15%	
	100%	
6. COST		5%
< $10 a Filter	50%	
# of Filters Neccessary for Application	50%	
	100%	

7. AVAILABILITY		5%
		100%
Volume Currently Manufactured	60%	
Length of Time on Market	40%	
	100%	

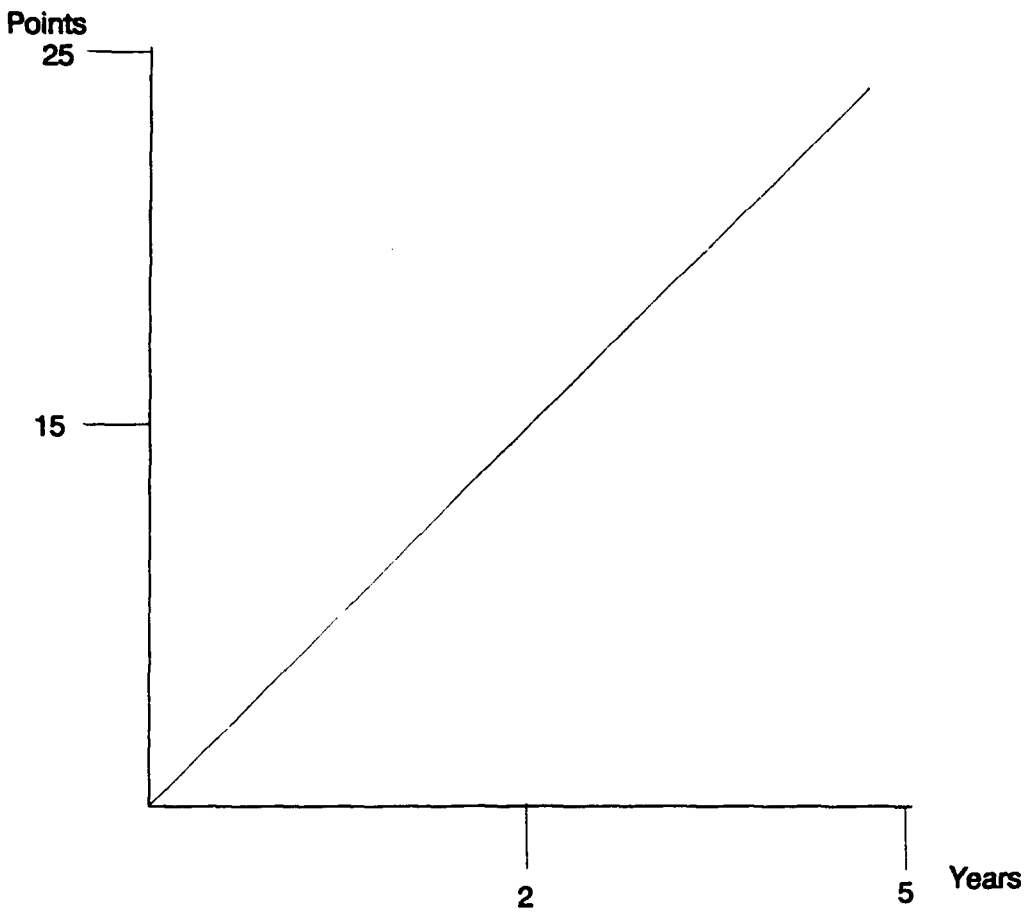
Flow Rate



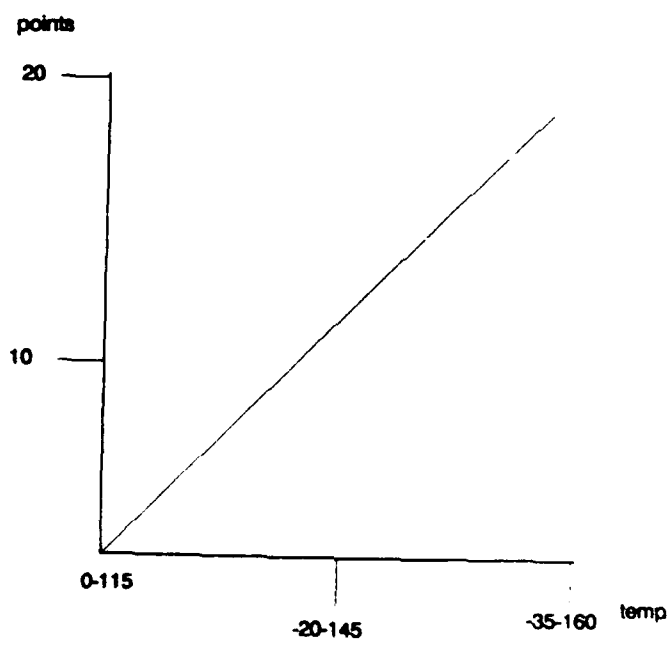
Liquid Pressure



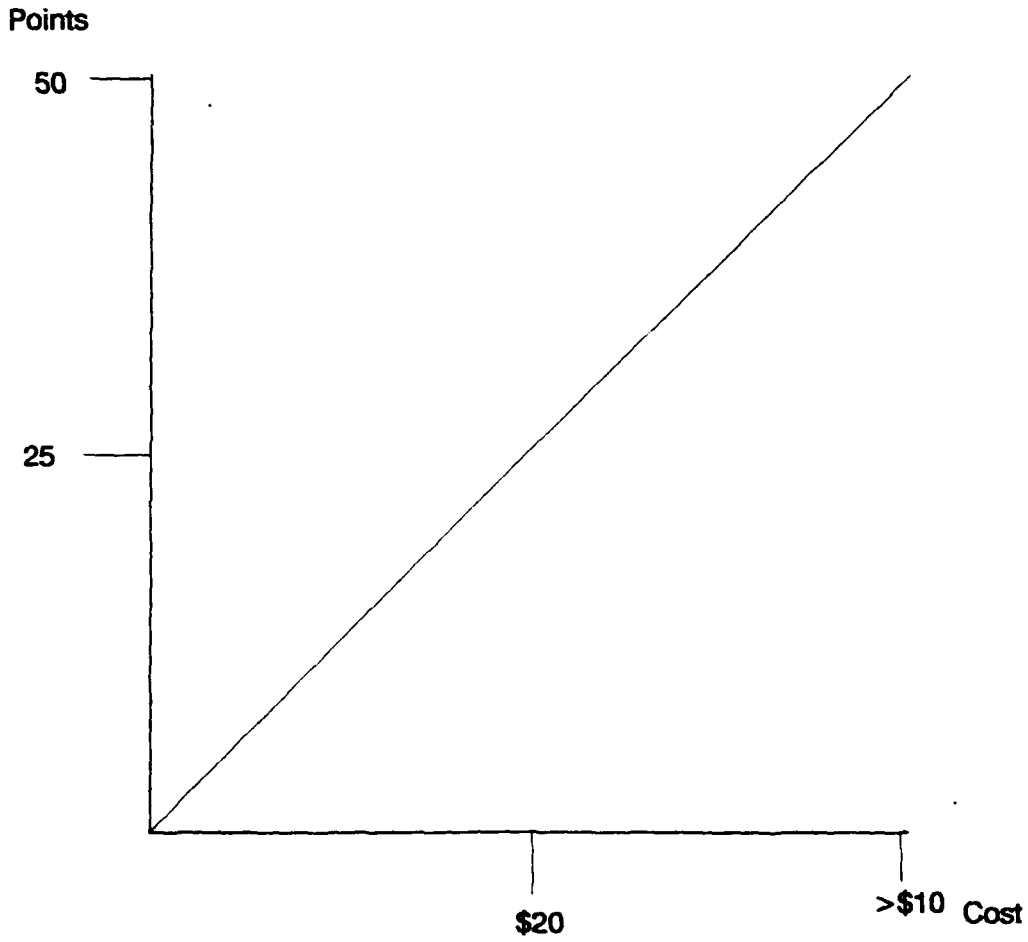
Shelf Life



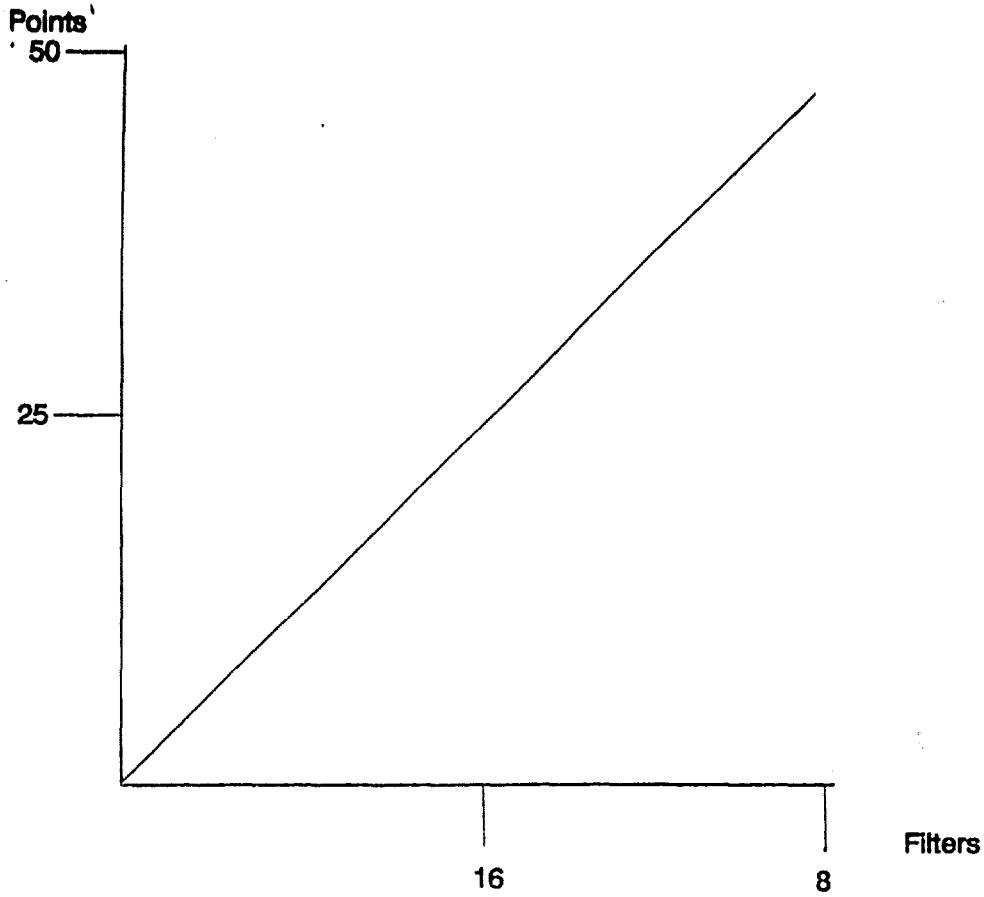
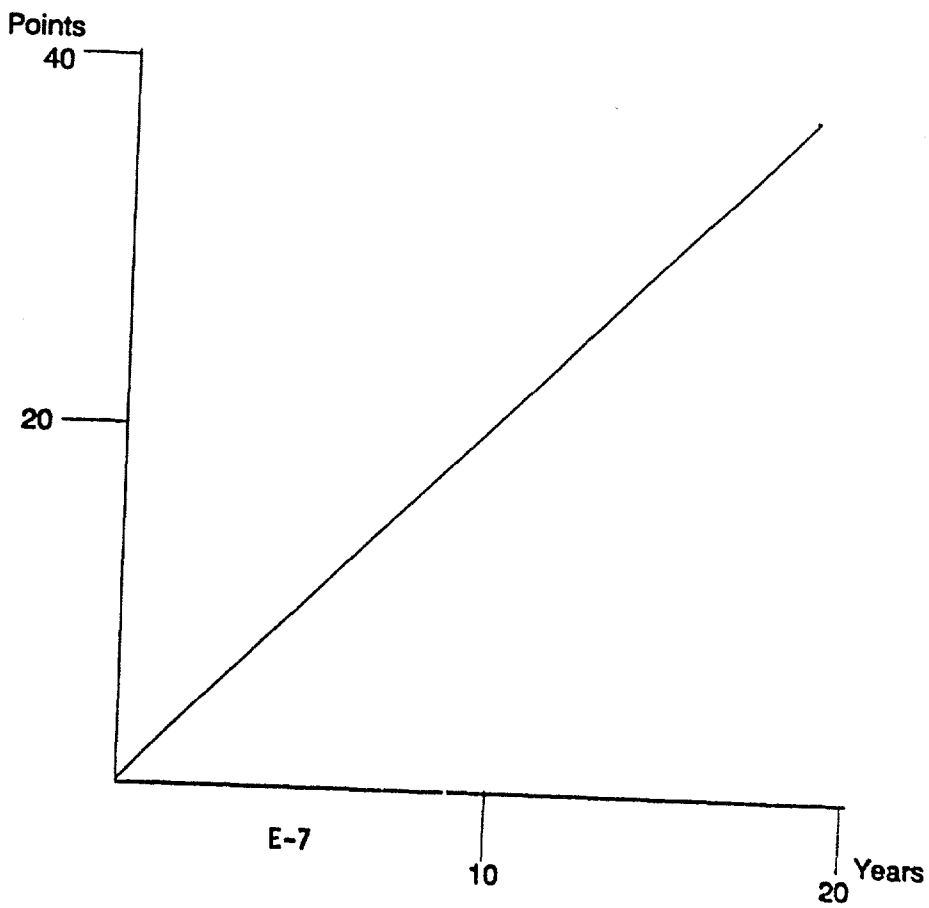
Storage Temperature



Cost



of Filters Needed



Length of Time on Market