SST REPORT NO. 920323

(1)

IDENTIFICATION AND EVALUATION OF BIOCIDES FOR ROWPU SYSTEMS

PHASE I FINAL REPORT

COVERING THE PERIOD AUGUST 23, 1991 THROUGH FEBRUARY 23, 1992

MARCH 23, 1992

(REVISED JULY 1, 1992)

UNCLASSIFIED

PREPARED UNDER CONTRACT NO. DAAK70-91-C-0065
FOR U. S. ARMY TROOP SUPPORT COMMAND
BELVOIR RD&E CENTER
FORT BELVOIR, VIRGINIA

SEPARATION SYSTEMS
TECHNOLOGY, INC.
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ABSTRACT

Mobile Reverse Osmosis Water Purification Units (ROWPU) have been used by the armed services for over a decade to produce potable water for field applications. While this technology has proven successful, a need exists to protect the membrane elements from microbial decomposition during long-term storage. Biocidal agents must be environmentally safe and effective at inactivating micro-organisms associated with membrane surfaces without compromising membrane performance. Phase I studies successfully demonstrated that appropriate methods and testing protocols for evaluating candidate biocides for their activity and compatibility with membranes were feasible. In addition, gamma radiation and several chemical biocide systems exhibited considerable promise.

Phase II of this program would extend this evaluation of chemical biocides and methodologies for element preservation. Potential biocides, identified from database surveys and other sources, would be screened to determine their microbicidal activity against biologically fouled membranes. Microbicidal activity would be determined by comparing transport properties before and after exposure to potential biocides. Candidate biocides would be further evaluated under dynamic flow conditions and in element soak tests to confirm membrane compatibility and long-term stability. Biocides would be ranked according to microbicidal activity, long-term stability, membrane compatibility, cost and environmental safety.

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1.0 INTRODUCTION

The objective of the Phase I feasibility program was (1) to identify existing and novel antimicrobial agents (i.e., biocides) for preservation of reverse osmosis membrane elements used in the ROWPU systems and (2) to determine the feasibility for biocide testing and performance evaluation. The program focused on Filmtec and Fluid Systems membranes currently used in all ROWPU's. The candidate biocides that were selected for evaluation are based on their reported disinfection activities, known or suspected effects on reverse osmosis membrane integrity and performance, safety and environmental properties, chemical stability and shelf life, ease of handling, commercial availability and cost.

The specific Phase I objectives included:

1. Identification of known biocides or other chemical compounds (or mixtures of compounds) that may have potential as membrane preservatives,

2. Selection of candidate biocides based on reported toxicological properties, microbicidal and other criteria,

3. Selection and/or development of appropriate methods and testing protocols for evaluating candidate biocides for their activity and compatibility, and

4. Preliminary activity and compatibility testing to validate testing protocols.

The Phase I activities focused on five areas:

1. Completion of a computer data base search for biocides suited for the requirements set forth for ROWPU reverse osmosis element storage.

2. Selection of approximately sixteen biocides to be evaluated on this program.

3. Procurement of ROWPU elements for testing and evaluation at both Separation Systems Technology and at the Orange County Water District Facility. All membrane used in the biocide study was derived from the aforementioned elements for biocide evaluations.

4. Reverse osmosis qualification testing of both Filmtec and Fluid Systems membranes, under seawater conditions, at Separation Systems Technology to qualify membrane samples for long term storage in each biocide. The purpose of this test was to determine what effect, if any, the biocides may have on the transport properties of the membrane.

5. Installation and integration of several element test vessels, on a slip stream, in the Orange County Water District's 5,000,000 gallon per day reverse osmosis plant operating on secondary treated municipal waste water. Both Filmtec and Fluid Systems membrane elements were operated for several weeks to foul and/or contaminate the membrane with microorganisms. Subsequently, the membrane

was removed from the elements and placed in the various biocides for long term storage. At the end of storage period, the membrane samples and the biocide solutions were analyzed for live microorganisms to determine the effectiveness of the biocide.

1.1 BIOCIDE SELECTION

The selection of the individual biocides for this study was determined after reviewing the following references;

1. A detailed literature search including a review of membrane related biocides.
2. A computer data base search.
3. Contact with a number of commercial biocide producing companies.
4. Consultation with microbiology researchers at several universities.
5. Reference to:
   Seymour S. Block, Disinfection, Sterilization and Preservation, Lea and Febiger Press, Philadelphia, 1983.
6. Consultation with Dr. Harry Ridgway, chief microbiologist at the Orange County Water District, on the operational experiences at Water Factory 21 - a 5,000,000 gallon per day reverse osmosis plant operating on secondary treated municipal waste water since 1972.
7. Consultation with Dr. Charles Moody of the U.S. Bureau of Reclamation.
8. A review of several commercial seawater reverse osmosis plant histories with the plant engineers.

After screening a large number of candidates, the following were selected for evaluation:

1. Gamma radiation:

   Types of ionizing radiation are x-rays, gamma-rays, high speed electrons (beta-rays), protons and alpha-rays. In practice, beta - rays and especially gamma-rays (usually produced from a cobalt 60 source) are employed. Ionizing radiation is believed to exert its effect by bringing about single-strand or double-strand breakages in DNA, the latter being more lethal. In order to establish a sterilizing dose for a given material, one must be able to balance the radiation tolerance of a material against that dose of radiation considered necessary to establish sterility. For relatively inert materials such as plastics, large doses can be used with relative impunity. The use of gamma radiation to sterilize hospital supplies such as plastic hypodermic syringes, sutures, and containers is the main commercial application for ionizing radiation. Thus, it follows that sterilization of spiral-wound ROWPU reverse osmosis membrane elements by gamma radiation is a very promising candidate for evaluation.

2. Quaternary ammonium compounds:

These surface active agents encompass a large group of compounds that have widespread use as sanitizing and disinfecting agents. The quaternary ammonium compounds are water-soluble cationic surface-active agents that inhibit microorganisms in low concentrations. Although the quaternary ammonium compounds are inherently effective biocides, they have been found to be incompatible with a large number of materials, especially anionic compounds. The latter is of some concern, particularly with the negatively charged Filmtec membrane. To neutralize the negative charge on the membrane surface, it may be necessary to increase the ionic strength of the biocide solution with salts. Both Cetyltrimethylammonium p-toluene sulfonate and benzalkonium chloride (C12, H25, N, C9,H13,Cl) were evaluated.

3. Ethylene diaminetetraacetic acid (EDTA):

Extensive studies on mode of action reviewed by Wilkenson (1975) relate essentially to metal binding by EDTA, especially magnesium, for Pseudomonas species in general. It appears that the outer membrane of gram-negative cells, i.e., the lipopolysaccharide, is structurally stabilized by Mg^{++}. Removal of Mg^{++} by EDTA complexing disorients the outer membrane exposing the thin (one-molecular-layer) peptidoglycan sacculus to environmental insult, including permeability to many antimicrobial agents.

4. Mixture of ethylene diaminetetraacetic acid (EDTA) and quaternary ammonium compounds:

EDTA has been demonstrated to increase the activity of benzalkonium chloride against gram-negative organisms. It appears that EDTA is synergistic with these compounds. The effectiveness of EDTA extends the utility of quaternary ammonium compounds.

5. Benzoic acid:

Benzoic acid is one of the oldest antimicrobial compounds that has been used in the food and drug fields. Generally, concentrations of 0.1 to 0.5% of the compound, incorporated as sodium benzoate, have been used effectively. The advantageous features are low toxicity, low price and ease of incorporation or formulation. Benzoic acid is effective against bacteria in acid media at a level of 0.15% and in neutral media at 0.2% but is inactive in alkaline media.

6. Boric acid:

The undissociated acid is the active form. It is mainly active against yeasts with less activity against molds.

7. Mixture of benzoic acid and boric acid (Memstore):

Memstore, a synergistic system based on a benzoic acid-boric acid mixture.

8. Mixture of methylchloroisothiazolinone and methyl isothiazolinone:

Kathon CG is a mixture of methylchloroisothiazolinone and methyl isothiazolinone. It is supplied as a water soluble formulation. Its broad-spectrum activity and compatibility with other materials are complemented by low toxicity at recommended use levels.

9. Mixture of glycerin and sodium bisulfite:

The mixture was run as a control, since Filmtec ROWPU elements are presently stored in this solution.

10. Glutaraldehyde:

Glutaraldehyde was run as a control since Fluid Systems ROWPU elements are presently stored in this solution. Glutaraldehyde has been shown to exhibit potent activity against a range of fungi. Vegetative bacteria are readily susceptible to the action of glutaraldehyde. However, there are reports in the literature of resistance of microorganisms to glutaraldehyde. It is possible that the latter may be attributed to contamination. The presence of various types and amounts of organic and inorganic materials as well as changes in pH may lead to adsorption, alteration, or inactivation of the disinfectant, significantly reducing recommended effective concentrations. Also, substandard preparation of the "activated" disinfectant, contamination of solutions, failure to replace solutions that have deteriorated on standing, or even dilution of residual glutaraldehyde solution may all modify the response of a particular species to the disinfectant, resulting in possible contamination. Due attention should therefore be exercised in the use of glutaraldehyde, as with any disinfectant, to avoid such occurrence.

11. Sorbic acid:

Sorbic acid was introduced as a preservative in recent years as a result of its history as a safe and effective food additive. It is more effective than benzoic acid as an antifungal agent, but, like benzoic and other acids, it is active only as the undissociated molecule. It has been shown that sorbic acid was effective against a variety of soil microorganisms at concentrations of 0.05% at pH 5.1, but at pH 6.0, 0.20% was required to inhibit growth. In general, it appears that sorbic acid is an effective preservative for acidic formulations. Various investigators have examined the interaction between sorbic and nonionic surfactants. It was generally found that sorbic ac'd retained sufficient activity to inhibit bacterial and fungal growth.

12. Salicylic acid:

Salicylic acid, or o-hydroxybenzoic acid, is a white crystal that dissolves in water at a level of 0.2 g/100 g of water at room temperature. Its pKa is 2.97. Salicylic acid reacts with proteins, damaging the plasma of microbial cells and probably interfering with enzyme activity. Salicylic acid interferes with pantothenic acid formation, which is necessary for many organisms. It is more effective against yeasts and molds than against bacteria, but it is more effective against bacteria

than is benzoic acid. Salicylic acid can be used only in highly acidic environments because of its dissociation behavior (dissociation constant of 1.07 x 10-3).

13. Mixture of glycerin and (C9, H10, 03) - Progard:

A commercial mixture of glycerin and a (C9, H10, 03) compound sold as a membrane preservative. The recommended pH is 5.5. It is believed that the biocide component is either a benzoic acid or benzaldehyde derivative.

14. 1-Bromo-3-chloro-5,5-dimethylhydantoin(BCDMH):

BCDMH is a safe, effective alternative to chlorine-based oxidizing biocides and non-oxidizing biocides for microbiological control in industrial cooling waters. In water, BCDMH releases the active bromine disinfection species, hypobromous acid. BCDMH effectively controls bacterial, algal, and fungal slimes. In addition, it is registered by the United States Environmental Protection Agency.

15. Formaldehyde condensate: 2-Bromo-2-nitro-1,3-propane diol, (BNPD):

Many preservatives have been developed whose activities are based on the gradual release of formaldehyde. Such products retain the antimicrobial properties of formaldehyde while avoiding the odor and volatility associated with formaldehyde. Among those compounds that have antimicrobial activity only after decomposition are those based on putative formaldehyde release. This includes a large number of compounds, both cyclic and acyclic, representing a diverse array of structures. The initial reaction in the decomposition of BNPD in aqueous solutions results in the liberation of 2-bromo-2-nitroethanol and formaldehyde. Broad spectrum activity is an important requirement for an antimicrobial. BNPD is highly effective against gram negative and gram positive bacteria. BNPD is more effective against bacteria than against fungi and yeasts. However, its effectiveness against the latter increases at higher concentrations. Where fungal contamination is a problem, BNPD can be used in conjunction with other preservatives to effect control.

16. Mixture of benzalkonium chloride and EDTA:

A mixture of these compounds is reported to exhibit synergistic biocidal effects.

1.2 METHODS AND MATERIALS

Polyetherurea and polyamide thin-film composite membrane samples were cut from both Fluid Systems and Filmtec spiral-wound ROWPU elements. The location of the membrane samples both within the element and within each sheet were recorded. On a given strip of membrane, six samples were removed for the biocide study. Three samples were tested in reverse osmosis at 800 psi applied pressure on ASTM synthetic seawater. A minimum rejection of 98.5% was required to qualify the membrane samples for the biocide study. Subsequently, the three alternating samples were placed into various concentrations of the selected biocide solutions at a given pH and stored at room temperature in a dark container. A sodium bicarbonate-hydrochloric acid buffer solution was employed. The three samples stored in the biocide solutions were tested under the same aforementioned conditions after about seventy days to determine if the membrane transport properties were detrimentally affected by the biocides. Seventeen (17) biocides, including gamma irradiation, were selected for study. Results of these studies are presented below.

2.0 GAMMA IRRADIATION STUDIES FOR MEMBRANE STERILIZATON

Radiation sterilization is a highly reliable, cost competitive, low-temperature sterilizing process. Two types of ionizing radiation, gamma and beta, are generally used for this application. Contact sterilizers favor gamma radiation, characterized by its deep penetration and low dose rates, over beta particles, characterized by low penetration and high dose rates.

Gamma radiation is attractive as a method for sterilizing ROWPU reverse osmosis elements since the elements are often stored for several years before use. The ROWPU elements would be irradiated soon after assembly and packaging by the element manufacturer. In addition, it may be beneficial to incorporate a chemical biocide into the element packaging, prior to irradiation, as an additional safeguard. For sterilization in the field, the latter biocide could be readministered.

In Phase I of this program, the effects of gamma radiation on the transport properties of both Filmtec and Fluid Systems membranes were determined. In a parallel study, the effectiveness of gamma radiation for sterilization was determined with both Filmtec and Fluid Systems membranes that had been fouled with microorganisms during reverse osmosis operation on munincipal waste water at Orange County Water District.

2.1 BENEFITS AND APPLICATIONS OF GAMMA PROCESSING

Gamma processing is now the preferred sterilization method of all major medical companies around the world. Radiation enables the sterilization of medical products within their own sealed packaging. Irradiation generates very little heat and is considered a cold process, permitting the sterilization of heat sensitive materials. In addition, it leaves no harmful residue.

The many uses of irradiation has rapidly expanded to include the sterilization or decontamination of some pharmaceutical materials and containers, laboratory supplies, cosmetic materials, containers and applicators, various food packaging products, and food itself.

2.2 MECHANISM

The nucleic acids and proteins present in all micro-organisms are each adversely affected by gamma rays emitted in the radioactive decay of cobalt-60. However, the disruption of nucleic acids, which contain information essential for growth, is substantially more crucial that the disruption of proteins. The most critical nucleic acid, DNA, contains the blue print for future generations within its exact structure. Therefore, any disruptive effects of ionizing radiation on life, focuses on damage done to DNA.

The principal effect of intensive gamma ray exposure on DNA is depolymerization. In this reaction, it is essential that both nucleotide strands are ruptured, since repair enzymes can regenerate the complete DNA helix from the information present on a single strand. The ionizing radiation environment also interacts with the base, sugar, and phosphate units of the nucleotide. Disruption of the base units, the most sensitive portion of the nucleotide, can lead to intrastrand or interstrand cross links in the DNA (biologically inactive structures).

In addition to the direct kill mechanism, indirect effects significantly contribute to the demise of DNA. These effects are dependent on the presence of water and oxygen. Water is dissociated in the presence of ionizing radiation, forming hydroxyl radicals. These radicals attack the bases and also extract hydrogen from the sugar units which ultimately results in scissions of sugar-phosphate bonds. Irradiation under aerobic conditions increases the extent of damage to DNA. Formation of peroxy radicals promotes breakage of the deoxyribose-phosphate bond.

At an absorbed dose of 2-3 Mrads, only a small fraction of the linking bonds is ruptured. However, for a DNA molecule, an absorbed dose of 2-3 Mrads causes approximately 10 to the 5th chain scissions, a sufficient amount to kill all micro-organisms in a packaged product and preclude enzyme repair processes.

2.3 RADIATION PROCESSING FACILITIES

An irradiation facility consists of a cobalt 60 energy source, an irradiator building with a processing room, a material handling system, and a warehouse. The products to be irradiated are transported into and out of the processing room on an automated conveyor system and in their shipping containers. The irradiation process is extremely safe and does not make materials radioactive. In fact, irradiated goods can be safely handled and used immediately after treatment. The irradiation processing industry is governed by strict and comprehensive safety regulations. As a result, extensive safety features are built into each system.

2.4 GUIDELINES FOR VALIDATING THE GAMMA STERILIZATION PROCESS

The AAMI guidelines for gamma sterilization of medical devices lists five basic steps. These serve to validate the minimum radiation dose required to ensure that the product and package content are completely sterile. The five steps are:

1. Materials Compatibility

2. Dose Setting

3. Product Loading Pattern

4. Dose Distribution Pattern

5. Cycle Timer Setting

In the Phase I program we were only concerned with (1) and (2).

Each polymer reacts differently to ionizing radiation. It is important to verify that the maximum dose likely to be administered will not have a detrimental effect on the transport properties of the membranes. Thus, membrane samples were irradiated to the highest dose likely to be encountered during routine processing; to date, the highest dose that the membranes were exposed was 2.6 Mrads.

The chances of one organism surviving after irradiation, decreases logarithmically with increasing dosage. However, it is important to take into account microbial population characteristics which define its pre-sterilization bioburden. Relevant characteristics include:

1. The magnitude of the population, and

2. The resistance properties of the population to radiation.

A higher minimum dose will be required for membranes with a higher bioburden that for membranes with a lower bioburden. Most of these factors can be overcome simply by using an "overkill" dose level. This term typically applies to a minimum dose level of 2.5 Mrads. To validate the "overkill" level, it is common to employ a test procedure known as the modified Kilmer Method in which a give number of membranes are irradiated at 1.01 + 0.05 Mrads. Following irradiation, a membrane sterility test is performed. Results fall into three basic categories:

1. A yield of no surviving organisms validates the 2.5 Mrad dose,

2. A yield of one survivor requires a re-test, or

3. A yield of two or more survivors suggests the need to evaluate and correct those factors in the production process causing a high bioburden.

2.5 EXPERIMENTAL RESULTS

Polyetherurea and polyamide thin-film composite membrane samples were taken from both Fluid Systems and Filmtec spiral-wound ROWPU elements, respectively. The location of the membrane samples both within the element and within each sheet were recorded. On a given strip of membrane, six samples were removed for the gamma radiation study. Three samples were tested in reverse osmosis at 800 psi applied

pressure on ASTM synthetic seawater; a minimum of 98.5% rejection was required to qualify the membrane samples for the irradiation study. The three alternating membrane samples were packaged in a sealed polyethylene bag for subsequent exposure to irradiation. The membranes were gamma irradiated at various dose levels and temperatures as follows:

1. 2.6 Mrads at 60°C
2. 2.5 Mrads at ambient temperature (Cooled)
3. 2.1 Mrads at 60°C
4. 1.6 Mrads at 60°C

Three sets of membranes from both Fluid Systems and Filmtec were irradiated under each of the aforementioned conditions; each set of membrane contained three individual samples. In total, seventy two (72) membrane samples were irradiated. After irradiation, the membranes were tested in reverse osmosis at the same conditions as the controls. A summary of the results of the study are presented in Table 1. A summary of the individual test results are detailed in Table 2; the individual test results are given in Appendix A and B.

These studies have shown that there is limited deterioration of the Filmtec polyamide membrane upon exposure to gamma radiation. Fluid Systems membranes, on the other hand, degraded significantly.

It is well known that the Fluid Systems polyetherurea membrane is both chemically and physically less durable than the Filmtec polyamide membrane. In the presence of ionizing radiation, water is dissociated to form the hydroxyl radical. It is likely that the degradation of the membrane is related to the presence of the hydroxyl radical. In the future, it may be necessary to include a radical scavenger in the aqueous environment of the membrane.

In a parallel study, biofilms were formed on the surfaces of both Fluid Systems and Filmtec membranes in spiral elements that were operated for several months on a municipal waste water feed at the Orange County Water District's Water Factory - 21 5,000,000 gallons per day reverse osmosis plant. Subsequently, the biofouled membranes were removed from the elements, cut into rectangular sections measuring approximately 4" x 12", place in sealed plastic bags and irradiated under different conditions. A control sample was left unirradiated. The inactivation of reverse osmosis biofilm bacteria by gamma irradiation is shown in Figure 1.

Following irradiation, the membrane surfaces were scraped with a sterile razor blade to remove biofilm bacteria. The scrapings were resuspended in 5.0 mL of sterile buffer solution and the number of surviving cells per mL determined by plating appropriate dilutions onto R2A agar growth medium. Air-born contamination resulting from scraping and related handling was probably responsible for the two instances where a very low number of bacteria were directed following irradiation. These low values were based on the appearance of a single colony on a plate. It can be concluded that gamma irradiation produced a total kill of the biofilm.

In summary, these results are very promising. Gamma radiation promises to be an excellent method for sterilizing ROWPU elements and will be conducted during Phase II.

2.6 GAMMA STERILIZATION COSTS

Pricing schedules for gamma irradiation of ROWPU elements is based on the tote size and loading. A tote contains the ROWPU elements while it moves through the radiation room. The tote's internal dimensions are 20" X 50" X 36". Thus, approximately 15 ROWPU elements could be placed in a single tote. The charge for a single tote, for 2.5 Mrads minimum dosage, is $39.00. On this basis, the sterilization cost per elements would be in the order of $3.00. Special handling charges such as refrigeration, pallet wrapping, etc. would be additional. Thus, the cost of sterilization by gamma irradiation is competitive with chemical biocides.

Table 1

MICROBIAL EFFECTIVENESS OF GAMMA IRRADIATION AND ITS EFFECT ON THE TRANSPORT PROPERTIES OF FLUID SYSTEMS AND FILMTEC THIN-FILM COMPOSITE MEMBRANES USED IN THE U.S. ARMY ROWPU DESALINATION UNITS

MEMBRANE IDENTIFICATION				MEMBRANE TRANSPORT PROPERTIES				CANDIDATE FOR ADDITIONAL EVALUATION IN PHASE II
ELEMENT DESIGNATION		RADIATION		CHANGE AFTER EXPOSURE TO RADIATION				
FSD	FILMTEC	TYPE	MRADS	WATER PASSAGE (% CHANGE)		SALT PASSAGE (% CHANGE)		
3728-44		GAMMA	2.6(60°C)	-0.6		+23.1		
	A8722-44	GAMMA	2.6(60°C)		-32.1		-18.1	YES
3728-45		GAMMA	2.6(60°C)	+22.2		+63.1		
	A8722-45	GAMMA	2.6(60°C)		+30.0		+24.1	
3728-46		GAMMA	2.6(60°C)	+22.7		+98.5		
	A8722-46	GAMMA	2.6(60°C)		-40.0		-3.0	
3728-51		GAMMA	2.5(COLD)	+15.4		+43.3		
	A8722-53	GAMMA	2.5(COLD)		+2.5		+29.0	YES
3728-53		GAMMA	2.5(COLD)	+10.1		+31.7		
	A8722-54	GAMMA	2.5(COLD)		-1.5		-18.0	
3728-54		GAMMA	2.5(COLD)	+18.9		+46.7		
	A2165-55	GAMMA	2.5(COLD)		-9.7		+27.5	
3728-58		GAMMA	2.1(60°C)	+18.7		+109		
	A2165-59	GAMMA	2.1(60°C)		-17.5		+65.6	YES
3728-59		GAMMA	2.1(60°C)	+10.3		+109		
	A2165-60	GAMMA	2.1(60°C)		-3.1		+30.5	
3728-60		GAMMA	2.1(60°C)	+13.4		+97.6		
3730-65		GAMMA	1.6(60°C)	+20.8		+45.6		
	A2165-64	GAMMA	1.6(60°C)		-8.8		-5.7	YES
3730-66		GAMMA	1.6(60°C)	+14.6		+40.2		
	A2165-66	GAMMA	1.6(60°C)		+4.1		+23.5	
3730-68		GAMMA	1.6(60°C)	+22.7		+63.1		
	A2165-67	GAMMA	1.6(60°C)		-15.0		+21.6	

Table 2

RADIATION STERILIZATION: EXPERIMENTAL CONDITIONS AND CRITICAL MEASUREMENTS

MEMBRANE IDENTIFICATION				MEMBRANE MEASUREMENTS - BEFORE AND AFTER GAMMA IRRADIATION							
				TRANSPORT PROPERTIES BEFORE IRRADIATION				TRANSPORT PROPERTIES AFTER IRRADIATION			
ELEMENT DESIGNATION		RADIATION		WATER FLUX (GFD)		COND. REJECTION (%)		WATER FLUX (GFD)		COND. REJECTION (%)	
FSD	FILMTEC	TYPE	MRADS								
3728-44		GAMMA	2.6(60°C)	16.7		99.0		16.6		98.7	
	A8722-44	GAMMA	2.6(60°C)		24.9		99.1		16.9		99.3
3728-45		GAMMA	2.6(60°C)	14.4		99.1		17.6		98.5	
	A8722-45	GAMMA	2.6(60°C)		25.3		99.2		17.7		98.9
3728-46		GAMMA	2.6(60°C)	15.4		99.2		18.9		98.4	
	A8722-46	GAMMA	2.6(60°C)		25.3		99.0		16.3		99.1
			AVG.	15.5	25.2	99.1	99.1	17.7	17.0	98.5	99.1
							CHANGE	+ 2.2	- 8.2	- 0.6	0
3728-51		GAMMA	2.5(COLD)	16.2		99.0		18.7		98.5	
	A8722-53	GAMMA	2.5(COLD)		20.0		99.0		20.5		98.7
3728-53		GAMMA	2.5(COLD)	17.9		99.0		19.7		98.6	
	A8722-54	GAMMA	2.5(COLD)		20.4		98.8		20.7		99.1
3728-54		GAMMA	2.5(COLD)	16.9		99.0		20.1		98.5	
	A2165-55	GAMMA	2.5(COLD)		22.7		99.1		20.5		98.9
			AVG.	17.0	21.1	99.0	98.97	19.5	20.6	98.5	98.9
							CHANGE	+2.5	-0.5	-0.5	0
3728-58		GAMMA	2.1(60°C)	21.9		98.7		26.0		97.1	
	A2165-59	GAMMA	2.1(60°C)		24.3		98.9		17.8		98.7
3728-59		GAMMA	2.1(60°C)	23.2		98.8		25.6		97.3	
	A2165-60	GAMMA	2.1(60°C)		22.5		99.3		21.8		99.1
3728-60		GAMMA	2.1(60°C)	24.6		98.5		27.9		97.0	
	A2165-61	GAMMA	2.1(60°C)		23.4		99.2		17.7		98.7
			AVG	23.2	23.4	98.7	99.1	26.5	19.1	97.1	98.8
							CHANGE	+3.3	-4.3	-1.6	-0.3

Table 2 (Cont.)

RADIATION STERILIZATION: EXPERIMENTAL CONDITIONS AND CRITICAL MEASUREMENTS

MEMBRANE IDENTIFICATION				MEMBRANE MEASUREMENTS - BEFORE AND AFTER GAMMA IRRADIATION							
				TRANSPORT PROPERTIES BEFORE IRRADIATION				TRANSPORT PROPERTIES AFTER IRRADIATION			
ELEMENT DESIGNATION		RADIATION			WATER FLUX (GFD)		COND. REJECTION (%)		WATER FLUX (GFD)		COND. REJECTION (%)	
FSD	FILMTEC	TYPE	MRADS									
3730-65		GAMMA	1.6(60°C)		19.2		98.5		23.2		97.8	
	A2165-64	GAMMA	1.6(60°C)			21.7		99.4		20.0		99.4
3730-66		GAMMA	1.6(60°C)		16.4		99.0		18.8		98.6	
	A2165-66	GAMMA	1.6(60°C)			21.8		99.1		21.2		98.9
3730-68		GAMMA	1.6(60°C)		18.5		98.6		22.7		97.8	
	A2165-67	GAMMA	1.6(60°C)			23.3		98.9		19.9		98.7
				AVG	18.0	22.3	98.7	99.1	21.6	20.4	98.1	99.0
								CHANGE	+3.6	-1.9	-0.6	-0.1

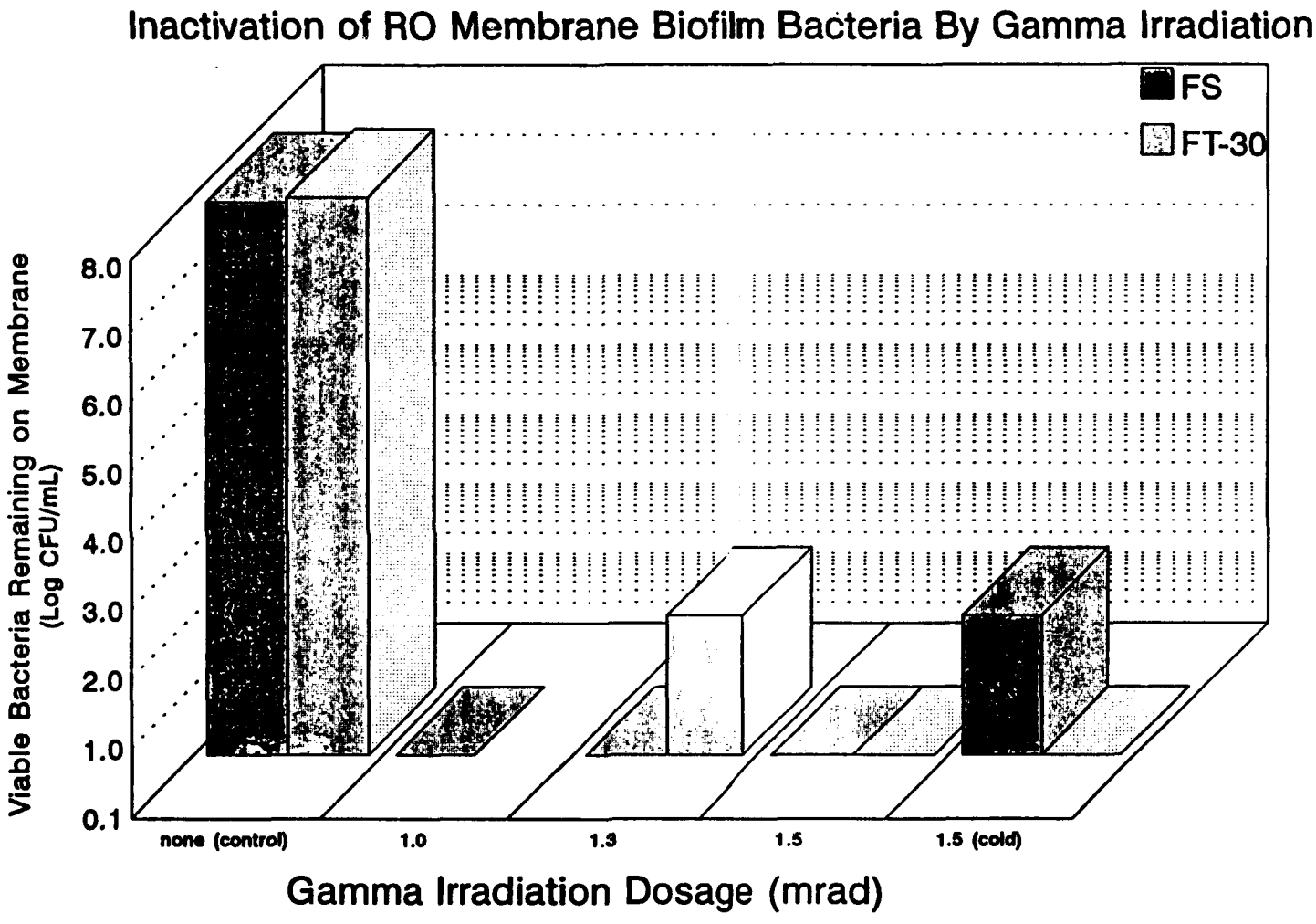

Figure 1 - Inactivation of Reverse Osmosis Biofilm Bacteria by Gamma Irradiation

3.0 MEMBRANE COMPATIBILITY TESTING WITH FIFTEEN CANDIDATE BIOCIDAL AGENTS

3.1 BACKGROUND/EXPERIMENTAL APPROACH

Antimicrobial agents may adversely affect membrane integrity and/or performance. In order to test for this possibility, 1.5 x 3.5 inch rectangular sections of membrane were removed from new Fluid Systems and Filmtec spiral-elements and performance rated in reverse osmosis tests for initial water flux and salt rejection at 800 psig on a synthetic seawater feed solution. A corresponding set of membranes samples were immersed in fifteen different candidate biocidal agents, or biocide combinations, at ambient temperature for up to three months. Low, medium and high concentrations of the biocidal agents in buffered solutions were used in the immersion tests. Tests were performed in triplicate. These tests were performed using aseptic techniques to eliminate the potential for microbial regrowth and/or metabolic processes. Sterile control membrane preparations were incubated under identical conditions in the buffered solution, but without added antibicidal agent.

After the membranes have soaked for the appropriate duration, the water flux and salt rejection of all membrane samples are determined in the same reverse osmosis test at 800 psig on a synthetic seawater feed solution. Any significant difference in the pre-soak and post-soak performance values, when compared with the untreated control preparation, can be interpretated as an effect of the biocidal agent on the membrane.

3.2 RESULTS

A summary of the pre-soak and post-soak reverse osmosis performance results are presented in Table 3. Growth prevention is expressed as "minimum inhibitory concentration" (MIC), i.e., the highest biocide dilution that results in complete growth inhibition (see Section 6.0). Detailed performance data sheets for each individual test described in Table 3 are shown in Table 4.

Extreme care was taken in removing the membrane samples from the spiral elements to minimize physical damage. The elements were flushed with a 50% glycerin solution prior to dissection to lubricate the membrane against spacer screen damage. This is particularly important for Fluid Systems membranes since it well known that these membranes are very delicate on the thin film surface and are easily damaged. There is also some concern about membrane damage induced by the 0-ring of the test cell during reverse osmosis testing. Ideally, a study of this type should be conducted with spiral elements to minimize and/or eliminate these variables. Thus, some variation in membrane performance, particularly salt rejection, can be expected due to membrane damage by excessive handling.

In addition to the fifteen biocides, a control solution without biocide was evaluated to establish a baseline variation in test performance. The results of this test are given in Table 4. The average change in water flux and salt rejection for the Fluid Systems membrane was +1.2 gfd and -0.4%, respectively. The average change in water flux and salt rejection for the Filmtec membrane was +2.0 gfd and -0.13%, respectively. Thus, any significant change in membrane transport properties, before and after immersion in

Table 3

MICROBIAL EFFECTIVENESS OF CANDIDATE CHEMICAL BIOCIDES AND THEIR EFFECT ON THE TRANSPORT PROPERTIES OF FLUID SYSTEMS AND FILMTEC THIN-FILM COMPOSITE MEMBRANES USED IN THE U.S. ARMY ROWPU DESALINATION UNITS.

MEMBRANE IDENTIFICATION		STORAGE CONDITIONS			MICROBIAL EFFECTIVENESS	MEMBRANE TRANSPORT PROPERTIES				CANDIDATE FOR ADDITIONAL EVALUATION IN PHASE II
ELEMENT DESIGNATION		BIOCIDE			GROWTH PREVENTION	CHANGE AFTER EXPOSURE TO BIOCIDE				
FSD	FILMTEC	TYPE	CONC. (WT-%)	EXPOSURE (DAYS)	(MIC)	WATER PASSAGE (% CHANGE)		SALT PASSAGE (% CHANGE)		
3728-1		BENZALKONIUM	0.5	67	1024	-6.9		+140.		NO
	A1874-1	CHLORIDE (1)	0.5	67			-		-	
3728-2			0.1	67		-11.7		+92.5		
	A1874-2		0.1	67			-92.0		+592	
3728-3			0.01	68		-5.0		+45.4		
	A1874-3		0.01	68			-714		+718	
3728-4		SODIUM BENZOATE/	2.0	68	4	-15.0		+55.5		NO
	A1874-4	SODIUM BORATE (2)	2.0	68			-28.2		-52.0	
3728-5		GLYCERIN/C9, H10,03	20.0	69	INCOMPLETE	+4.2		+4.0		
	A1874-5	(3)	20.0	69			-20.3		+717*	REPEAT TESTS
3728-6		SUBSTITUTED	0.50	69	INCOMPLETE	+13.9		+110		YES
	A1874-6	ISOTHIAZOLINONE	0.50	69			-16.7		-3.3	
3728-7		(4)	0.13	69		+15.4		+22.9		
	A1874-7		0.13	69			-23.9		+28.3	
3728-8			0.01	69		-5.5		+4.8		
	A1874-8		0.01	69			-16.1		+42.5	

* MEMBRANES TOOK UP DYE ON SURFACE AFTER TEST - MAY BE PHYSICAL DAMAGE

Table 3 (Cont.)

MICROBIAL EFFECTIVENESS OF CANDIDATE CHEMICAL BIOCIDES AND THEIR EFFECT ON THE TRANSPORT PROPERTIES OF FLUID SYSTEMS AND FILMTEC THIN-FILM COMPOSITE MEMBRANES USED IN THE U.S. ARMY ROWPU DESALINATION UNITS.

MEMBRANE IDENTIFICATION		STORAGE CONDITIONS		MICROBIAL EFFECTIVENESS	MEMBRANE TRANSPORT PROPERTIES				CANDIDATE FOR ADDITIONAL EVALUATION IN PHASE II
ELEMENT DESIGNATION		BIOCIDE		GROWTH PREVENTION	CHANGE AFTER EXPOSURE TO BIOCIDE				
FSD	FILMTEC	TYPE	CONC. (WT-%) EXPOSURE (DAYS)	(MIC)	WATER PASSAGE (% CHANGE)		SALT PASSAGE (% CHANGE)		
3728-10		BROMOCHLORODIMETHYL	100MG/L 70	2	+30.8		+183		NO
	A1874-9	HYDANTOIN (5)	100MG/L 70			-32.5		-12.1	
3728-11			10MG/L 70		+22.4		+139		
	A1874-10		10MG/L 70			-32.0		-16.8	
3728-12			1MG/L 70		+4.6		+42.8		
	A1874-11		1MG/L 70			-29.8		+37.4	
3728-13		BROMONITROPROPANE	0.5 69	64	-13.3		+91.8		NO
	A1874-12	DIOL (6)	0.5 69			-54.5		+3.2	
3728-15			0.1 70		-4.0		+56.3		
	A1874-13		0.1 70			-53.7		-10.6	
3728-17			0.01 70		-4.9		+54.1		
	A1874-14		0.01 70			-42.4		+100	
3728-18		CETYLTRIMETHYL	0.5 76	256	+18.3		+42.8		NO
	A1874-15	AMMONIUM	0.5 76			-67.5		+103	
3728-20		p-TOLUENE	0.1 76		-1.6		+108		
	A1874-16	SULFONATE(7)	0.1 76			-68.8		+71.9	
3728-21			0.01 75		+21.5		-50.0		
	A1874-17		0.01 75			-67.6		+293	
3728-22		SODIUM	0.5 75	8	+12.2		+34.9		NO
	A9067-19	BENZOATE (8)	0.5 75			-24.7		+35.5	
3728-24			0.1 75		+14.0		-42.4		
	A9067-21		0.1 75			-4.9		+98.7	
3728-26			0.01 75		+4.1		+12.6		
	A9067-23		0.01 79			-10.7		+230	

Table 3 (Cont.)

MICROBIAL EFFECTIVENESS OF CANDIDATE CHEMICAL BIOCIDES AND THEIR EFFECT ON THE TRANSPORT PROPERTIES OF FLUID SYSTEMS AND FILMTEC THIN-FILM COMPOSITE MEMBRANES USED IN THE U.S. ARMY ROWPU DESALINATION UNITS.

MEMBRANE IDENTIFICATION		STORAGE CONDITIONS		MICROBIAL EFFECTIVENESS	MEMBRANE TRANSPORT PROPERTIES				CANDIDATE FOR ADDITIONAL EVALUATION IN PHASE II
ELEMENT DESIGNATION		BIOCIDE		GROWTH PREVENTION	CHANGE AFTER EXPOSURE TO BIOCIDE				
FSD	FILMTEC	TYPE	CONC. (WT-%) EXPOSURE (DAYS)	(MIC)	WATER PASSAGE (% CHANGE)		SALT PASSAGE (% CHANGE)		
3728-29		EDTA(9)	0.5 75	1024	+18.3		+65.4		YES
	A9067-25		0.5 79			-20.6		+5.2	
3728-30			0.1 78		+8.6		+15.8		
	A9067-27		0.1 82			-4.5		-13.0	
3728-14			0.01 78		+8.0		+92.6		
	A9067-29		0.01 82			-12.8		-21.9	
3728-31		SODIUM BENZOATE/	0.5 74	512	+11.6		+36.3		YES
	A8722-34	EDTA (50/50) (10)	0.5 74			-12.3		-20.1	
3728-32			0.1 75		+18.7		+33.9		
	A8722-35		0.1 75			-12.1		-14.5	
3728-33			0.01 75		+8.8		+86.6		
	A8722-36		0.01 75			-10.6		-19.1	
3728-34		GLUTERALDEHYDE(11)	3.0 75	512	-12.2		+22.0		NO
	A8722-37		3.0 75			-95.0		+889	
3728-35			1.0 75		+1.3		+34.7		
	A8722-38		1.0 75			-88.0		+267	
3728-36			0.5 75		+0.5		+42.8		
	A8722-39		0.5 75			-80.5		+88.6	
3728-37		SODIUM BISULFITE	1.0 76	16	+6.1		+77.6		YES
	A8722-40	GLYCERIN (12)	20.0 76			+7.9		+26.0	

Table 3 (Cont.)

MICROBIAL EFFECTIVENESS OF CANDIDATE CHEMICAL BIOCIDES AND THEIR EFFECT ON THE TRANSPORT PROPERTIES OF FLUID SYSTEMS AND FILMTEC THIN-FILM COMPOSITE MEMBRANES USED IN THE U.S. ARMY ROWPU DESALINATION UNITS.

MEMBRANE IDENTIFICATION		STORAGE CONDITIONS		MICROBIAL EFFECTIVENESS	MEMBRANE TRANSPORT PROPERTIES				CANDIDATE FOR ADDITIONAL EVALUATION IN PHASE II
ELEMENT DESIGNATION		BIOCIDE		GROWTH	CHANGE AFTER EXPOSURE TO BIOCIDE				
FSD	FILMTEC	TYPE	CONC. (WT-%) EXPOSURE (DAYS)	PREVENTION (MIC)	WATER PASSAGE (% CHANGE)		SALT PASSAGE (% CHANGE)		
3728-38		CONTROL	70	-	+6.3		+20.3		-
	A8722-50	NO BIOCIDE (13)	70			+2.8		+21.4	
3728-40			88		+17.3		+52.9		
	A8722-51		88			+12.0		-5.6	
3728-43			87		-1.7		+36.0		
	A8722-52		87			+14.5		+10.2	
3728-48		SALICYLIC ACID (14)	0.2 89	4	+11.3		+55.3		YES
	A8722-47		0.2 89			-19.4		+45.6	
3728-49			0.1 91		+10.5		-1.2		
	A8722-41		0.1 91			-15.9		-26.4	
3728-50			0.01 91		+9.9		+26.0		
	A8722-49		0.01 91			-1.3		+7.0	
3728-55		BENZALKONIUM	0.5 94	1024	-8.2		+47.6		NO
	A2165-56	CHLORIDE/EDTA	0.5 94			-		-	
3728-56		MIXTURE (50/50) (15)	0.1 94		-1.3		+13.3		
	A2165-57		0.1 94			-		-	
3728-57			0.01 94		-5.1		-11.8		
	A2165-58		0.01 94			-81.8		+585	
3730-61		SORBIC ACID (16)	0.1 88	2	+22.5		-17.7		NO
	A2165-63		0.1 88			-25.7		-46.7	
3730-62			0.05 88		+18.0		+14.5		
	A2165-62		0.05 88			-21.5		-23.3	
3730-63			0.01 88		+27.2		+74.4		
	A2165-65		0.01 88			-5.7		+30.8	

BIOCIDE LEGEND

1. BENZALKONIUM CHLORIDE, C12 H25 N C9 H13 CL, ALSO C14 AND C16 HOMOLOGS, SIGMA CHEMICAL CO. B-1383
2. SODIUM BENZOATE-SODIUM BORATE MIXTURE, MEMSTORE
3. GLYCOL/C9 H10 03, PROGARD, ARGO SCIENTIFIC
4. 5-CHLORO-2-METHYL-4 ISOTHIAZOLIN-3-ONE (1.15%) / 2-METHYL-4-ISOTHIAZOLIN-3-ONE (0.35%), NALCO CHEMICAL CO.
5. BROMOCHLORODIMETHYLHYDANTOIN, GREAT LAKES CHEMICAL CORPORATION
6. BROMONITROPROPANE DIOL, GREAT LAKES CHEMICAL CORPORATION
7. CETYTRIMETHAMMONIUM P-TOLUENE SULFONATE, SIGMA CHEMICAL CO. C-8147
8. SODIUM BENZOATE, ALDRICH CHEMICAL CO.
9. ETHYLENEDIAMINETETRACETIC ACID, DOW CHEMICAL CO.
10. SODIUM BENZOATE / EDTA (50/50), ALDRICH CHEMICAL CO. / DOW CHEMICAL CO.
11. GLUTERALDEHYDE, ALDRICH CHEMICAL CO.
12. SODIUM BISULFITE / GLYCERIN, ALDRICH CHEMICAL CO.
13. CONTROL - NO BIOCIDE
14. SALICYLIC ACID, ALDRICH CHEMICAL CO.
15. BENZALKONIUM CHLORIDE / EDTA MIXTURE, SIGMA CHEMICAL CO / DOW CHEMICAL CO.
16. SORBIC ACID, ALDRICH CHEMICAL CO.

Table 4

STATIC STORAGE OF FLUID SYSTEMS AND FILMTEC COMPOSITE MEMBRANES AS CANDIDATE CHEMICAL BIOCIDE SOLUTIONS EXPERIMENTAL CONDITIONS AND CRITICAL MEASUREMENTS

MEMBRANE IDENTIFICATION		STORAGE CONDITIONS				MEMBRANE MEASUREMENTS - BEFORE AND AFTER BIOCIDE							
						TRANSPORT PROPERTIES @ START				TRANSPORT PROPERTIES AFTER BIOCIDE			
ELEMENT DESIGNATION		BIOCIDE				WATER FLUX (GFD)		COND. REJECTION (%)		WATER FLUX (GFD)		COND. REJECTION (%)	
FSD	FILMTEC	TYPE	CONC. (WT-%)	pH	TIME IN BIOCIDE (DAYS)								
3728-1		BENZALKONIUM	0.5	7.1	67	26.2		98.8		28.0		96.9	
	A1874-1	CHLORIDE (1)	0.5	7.1	67		31.6		99.1		-		-
3728-2			0.1	7.0	67	18.7		99.3		16.5		98.6	
	A1874-2		0.1	7.0	67		31.4		98.6		2.5		90.1
3728-3			0.01	7.0	68	25.7		98.7		24.4		98.1	
	A1874-3		0.01	7.0	68		31.2		99.1		7.9		91.9
3728-4		SODIUM BENZOATE /	2.0	5.5	68	19.9		99.3		16.9		98.8	
	A1874-4	SODIUM BORATE (2)	2.0	5.5	68		29.1		98.5		20.9		99.3
3728-5		GLYCERIN / C9, H10,03	20.0	5.1	69	26.5		98.8		27.6		98.7	
	A1874-5	(3)	20.0	5.1	69		30.0		99.1		23.9		92.1*
3728-6		SUBSTITUTED	0.50	7.0	69	23.8		98.7		27.1		97.1	
	A1874-6	ISOTHIAZOLINONE (4)	0.50	7.0	69		28.8		98.9		24.0		98.9
3728-7			0.13	7.1	69	15.6		98.9		18.0		98.5	
	A1874-7		0.13	7.1	69		30.6		99.1		23.3		98.7
3728-8			0.01	7.1	69	20.1		98.7		19.0		98.5	
	A1874-8		0.01	7.1	69		28.6		99.2		24.0		98.8

* MEMBRANES TOOK UP DYE ON SURFACE AFTER TEST - MAY BE PHYSICAL DAMAGE

Table 4 (Cont.)

STATIC STORAGE OF FLUID SYSTEMS AND FILMTEC COMPOSITE MEMBRANES AS CANDIDATE CHEMICAL BIOCIDE SOLUTIONS EXPERIMENTAL CONDITIONS AND CRITICAL MEASUREMENTS

MEMBRANE IDENTIFICATION		STORAGE CONDITIONS				MEMBRANE MEASUREMENTS - BEFORE AND AFTER BIOCIDE							
						TRANSPORT PROPERTIES @ START				TRANSPORT PROPERTIES AFTER BIOCIDE			
ELEMENT DESIGNATION		BIOCIDE				WATER FLUX (GFD)		COND. REJECTION (%)		WATER FLUX (GFD)		COND. REJECTION (%)	
FSD	FILMTEC	TYPE	CONC. (WT-%)	pH	TIME IN BIOCIDE (DAYS)								
3728-22		SODIUM	0.5	5.1	75	25.3		98.7		28.4		98.0	
	A9067-19	BENZOATE (8)	0.5	5.1	75		25.1		98.9		18.9		98.4
3728-24			0.1	5.1	75	24.3		98.5		27.7		97.8	
	A9067-21		0.1	5.1	79		24.6		98.9		23.4		97.5
3728-26			0.01	5.1	75	19.4		98.7		20.2		98.5	
	A9067-23		0.01	5.1	79		23.4		98.9		20.9		95.9
3728-29		EDTA(9)	0.5	5.1	75	22.3		98.5		26.4		97.4	
	A9067-25		0.5	5.1	79		24.3		99.0		19.3		98.9
3728-30			0.1	5.1	78	21.0		98.7		22.8		98.3	
	A9067-27		0.1	5.1	82		24.3		98.8		23.2		98.9
3728-14			0.01	5.1	78	23.8		98.9		25.7		97.6	
	A9067-29		0.01	5.1	82		25.0		98.7		21.8		98.8
3728-31		SODIUM BENZOATE	0.5	5.0	74	21.6		99.1		24.1		98.6	
	A8722-34	EDTA (50/50) (10)	0.5	5.0	74		24.3		99.1		21.3		99.2
3728-32			0.1	5.0	75	20.3		98.8		24.1		98.3	
	A8722-35		0.1	5.0	75		23.9		98.9		21.0		99.0
3728-33			0.01	5.0	75	15.9		99.3		17.3		98.6	
	A8722-36		0.01	5.0	75		24.5		99.1		21.9		99.1

Table 4 (Cont.)

STATIC STORAGE OF FLUID SYSTEMS AND FILMTEC COMPOSITE MEMBRANES AS CANDIDATE CHEMICAL BIOCIDE SOLUTIONS EXPERIMENTAL CONDITIONS AND CRITICAL MEASUREMENTS

MEMBRANE IDENTIFICATION		STORAGE CONDITIONS				MEMBRANE MEASUREMENTS - BEFORE AND AFTER BIOCIDE							
						TRANSPORT PROPERTIES @ START				TRANSPORT PROPERTIES AFTER BIOCIDE			
ELEMENT DESIGNATION		BIOCIDE				WATER FLUX (GFD)		COND. REJECTION (%)		WATER FLUX (GFD)		COND. REJECTION (%)	
FSD	FILMTEC	TYPE	CONC. (WT-%)	pH	TIME IN BIOCIDE (DAYS)								
3728-10		BROMOCHLORODIMETHYL	100MG/L	7.0	70	19.5		99.1		25.5		97.5	
	A1874-9	HYDANTOIN (5)	100MG/L	7.0	70		31.4		99.1		21.2		99.2
3728-11			10MG/L	7.0	70	22.3		98.8		27.3		97.1	
	A1874-10		10MG/L	7.0	70		28.1		98.9		19.1		99.0
3728-12			1MG/L	7.0	70	17.5		99.3		18.3		98.9	
	A1874-11		1MG/L	7.0	70		27.9		99.1		19.6		98.6
3728-13		BROMONITROPROPANE	0.5	6.0	69	18.1		99.2		15.7		98.4	
	A1874-12	DIOL (6)	0.5	6.0	69		28.6		98.9		13.0		98.9
3728-15			0.1	6.0	70	17..		99.1		16.8		98.5	
	A1874-13		0.1	6.0	70		28.3		98.7		13.1		98.9
3728-17			0.01	6.0	70	24.4		98.5		23.2		97.6	
	A1874-14		0.01	6.0	70		29.0		99.1		16.7		98.1
3728-18		CETYLTRIMETHYL	0.5	7.0	76	18.0		98.9		21.3		98.3	
	A1874-15	AMMONIUMN	0.5	7.0	76		28.0		98.8		9.1		97.6
3728-20		p-TOLUENE	0.1	7.1	76	19.3		99.3		19.0		98.5	
	A1874-16	SULFONATE(7)	0.1	7.1	76		28.5		98.9		8.9		98.0
3728-21			0.01	7.1	75	18.1		99.0		22.0		98.3	
	A1874-17		0.01	7.1	75		28.7		98.7		9.3		98.3

Table 4 (Cont.)

STATIC STORAGE OF FLUID SYSTEMS AND FILMTEC COMPOSITE MEMBRANES AS CANDIDATE CHEMICAL BIOCIDE SOLUTIONS EXPERIMENTAL CONDITIONS AND CRITICAL MEASUREMENTS

MEMBRANE IDENTIFICATION		STORAGE CONDITIONS				MEMBRANE MEASUREMENTS - BEFORE AND AFTER BIOCIDE							
						TRANSPORT PROPERTIES @ START				TRANSPORT PROPERTIES AFTER BIOCIDE			
ELEMENT DESIGNATION		BIOCIDE				WATER FLUX (GFD)		COND. REJECTION (%)		WATER FLUX (GFD)		COND. REJECTION (%)	
FSD	FILMTEC	TYPE	CONC. (WT-%)	pH	TIME IN BIOCIDE (DAYS)								
3728-34		GLUTERALDEHYDE(11)	3.0	5.0	75	21.2		98.7		18.6		98.3	
	A8722-37		3.0	5.0	75		24.2		99.1		1.2		88.9
3728-35			1.0	5.0	75	15.2		99.2		15.4		98.8	
	A8722-38		1.0	5.0	75		24.9		99.0		3.0		96.1
3728-36			0.5	5.0	75	22.1		98.8		22.2		98.2	
	A8722-39		0.5	5.0	75		24.1		99.1		4.7		98.2
3728-37		SODIUM BISULFITE	1.0	7.0	76	16.4		99.3		17.4		98.7	
	A8722-40	GLYCERIN (12)	20.0	7.0	76		24.1		99.0		26.0		98.7
3728-38		CONTROL		5.0	70	15.8		99.2		16.8		98.9	
	A8722-50	NO BIOCIDE (13)		5.0	70		21.8		99.2		22.4		99.0
3728-40				6.0	88	15.6		99.2		18.3		98.7	
	A8722-51			6.0	88		20.7		99.0		23.2		99.01
3728-43				7.0	87	17.6		99.2		17.3		98.9	
	A8722-52			7.0	87		20.7		98.9		23.7		98.7
3728-48		SALICYLIC ACID (14)	0.2	5.0	89	22.1		98.8		24.6		98.2	
	A8722-47		0.2	5.0	89		23.8		98.9		19.4		99.4
3728-49			0.1	5.0	91	17.1		99.0		18.9		99.0	
	A8722-41		0.1	5.0	91		23.9		99.0		20.1		99.2
3728-50			0.01	5.0	91	17.2		99.2		18.9		98.9	
	A8722-49		0.01	5.0	91		22.5		99.0		22.2		98.8

Table 4 (Cont.)

STATIC STORAGE OF FLUID SYSTEMS AND FILMTEC COMPOSITE MEMBRANES AS CANDIDATE CHEMICAL BIOCIDE SOLUTIONS EXPERIMENTAL CONDITIONS AND CRITICAL MEASUREMENTS

MEMBRANE IDENTIFICATION		STORAGE CONDITIONS				MEMBRANE MEASUREMENTS - BEFORE AND AFTER BIOCIDE							
						TRANSPORT PROPERTIES @ START				TRANSPORT PROPERTIES AFTER BIOCIDE			
ELEMENT DESIGNATION		BIOCIDE				WATER FLUX (GFD)		COND. REJECTION (%)		WATER FLUX (GFD)		COND. REJECTION (%)	
FSD	FILMTEC	TYPE	CONC. (WT-%)	pH	TIME IN BIOCIDE (DAYS)								
3728-55		BENZALKONIUM CHLORIDE	0.5	5.0	94	19.6		99.1		18.0		98.6	
	A2165-56	EDTA MIXTURE	0.5	5.0	94		20.0		99.3		-		-
3728-56		(50/50) (15)	0.1	5.0	94	22.7		98.8		22.4		98.5	
	A2165-57		0.1	5.0	94		21.4		99.1		-		-
3728-57			0.01	5.0	94	21.6		98.7		19.0		98.8	
	A2165-58		0.01	5.0	94		22.0		99.0		4.0		92.6
3730-61		SORBIC ACID (16)	0.1	5.0	88	16.9		98.8		20.7		99.0	
	A2165-63		0.1	5.0	88		22.6		99.3		16.8		99.6
3730-62			0.05	5.0	88	21.6		98.6		25.5		98.2	
	A2165-62		0.05	5.0	88		24.6		99.3		19.3		99.4
3730-63			0.01	5.0	88	15.1		99.3		19.2		98.8	
	A2165-65		0.01	5.0	88		21.0		99.3		19.8		99.1

biocides, must be greater than the baseline test control. This variation in membrane performance, particularly Fluid Systems membrane, may be due to membrane damage caused by handling. In nearly every case, the loss in rejection exhibited by Fluid Systems membrane after biocide exposure exceeded that of the control.

Several quaternary ammonium compounds were selected for evaluation since this class of materials has been shown to be an effective biocide. These compounds carry a net positive charge and, depending on the magnitude of the charge, can interact with some reverse osmosis membranes. The thin-film composite membrane removed from the Fluid Systems elements has an aliphatic/aromatic polyetherurea thin film while the membrane removed from the Filmtec element has a fully aromatic polyamide thin film; the Fluid Systems membrane surface is near neutral while the Filmtec membrane surface carries a slight negative charge in the form of carboxyl groups. Thus, it was not totally unexpected that Filmtec membrane showed a severe loss in water flux after storage in quaternary ammonium compounds such as benzalkonium chloride and cetyltrimethylammonium p-toluene sulfonate. (See Table 3). The water flux of the Fluid Systems membrane, on the other hand, was not affected. Nevertheless, more investigations should be conducted. Various types of quaternary ammonium compounds should be evaluated at various ionic strengths; by varying the ionic strength of the biocide solution it may be possible to minimize or eliminate the charge interaction of the biocide with the membrane.

Two commercial biocide solutions, Memstore from King Lee Chemicals (sodium benzoate/sodium borate) and Progard from Argo Scientific (glycerin/C9, H10, O3), produced uncertain results which appear to adversely affect the membranes. However, with commercial biocides, the solutions were used at the prescribed pH and concentration as designated by the supplier. Thus, only three membrane samples were used. In all other tests, three samples were used for each of three concentrations for a total of nine samples. These tests with commercial biocides should be repeated in Phase II with a greater number of samples and/or with membrane in spiral elements.

Formaldehyde, a very effective biocidal agent, has been used in the reverse osmosis industry for years. Unfortunately, formaldehyde is a hazardous material that can cause severe health problems. For these reasons, membrane manufacturers have switched to glutaraldehyde, a dialdehyde, which is somewhat less hazardous due to its lower vapor pressure. Glutaraldehyde is used as a preservative for the Fluid Systems membrane. For this reason, glutaraldehyde was included in the list of candidate biocides for this study. While glutaraldehyde did not affect the transport properties of the Fluid Systems membrane, it drastically lowered the water flux of the Filmtec membrane to an unacceptable level. Clearly, glutaraldehyde is not an acceptable candidate for the Filmtec membrane.

A mixture of sodium bisulfite and glycerin is used as a storage biocide for the Filmtec membrane. Accordingly, this biocidal mixture was evaluated in this study. The results would suggest that this biocide should qualify for further evaluation during Phase II of this program.

Substituted isothiazolinone, Kathon, appears to be acceptable for both membranes even though the water flux was somewhat lower for the Filmtec membrane than desired. This material should be evaluated more extensively during Phase II. Kathon is a readily

available commercial biocide currently used as a reverse osmosis membrane preservative.

Both ethylenediaminetetracetic acid (EDTA) and an EDTA-sodium benzoate mixture had little, if any effect, on the transport properties of either Fluid Systems or Filmtec membranes. These materials are excellent candidates for further study.

Bromonitropropane diol lowered the water flux of the Filmtec membrane by about 50%. Based on this observation, it does not appear to warrant further study as a general biocide for either Fluid Systems or Filmtec membranes.

4.0 SCREENING TESTS OF EXPERIMENTAL BIOCIDES USING BIOFOULED FLUID SYSTEMS AND FILMTEC MEMBRANES

4.1 BACKGROUND/EXPERIMENTAL APPROACH

The experimental strategy involved determination of whether a particular biocidal agent, or combination of agents, was able to prevent regrowth of bacteria in biofilms associated with reverse osmosis membrane coupons. Regrowth was determined by visual inspection of test tube cultures (each containing a fragment of a biologically fouled reverse osmosis membrane + growth medium) for turbidity after an appropriate period of incubation. Biocides tested in dilute R2A broth (Reasoner and Geldreich, 1987), a complex organic medium designed to support the growth of a wide variety of environmental bacteria, including those which might be associated with fouled reverse osmosis membrane surfaces (Ridgway, 1988). Biocides were defined as effective only if they completely prevented microbial growth and turbidity development in the broth cultures. However, microbial activity within the biofilm itself was not explored using this approach.

4.2 EXPERIMENTAL PROTOCOL

Fourteen different biocidal agents (or biocide combinations) were tested over a wide range of concentrations to determine their relative effectiveness in suppressing the growth of bacteria associated with reverse osmosis biofilms. Biofilms were formed on the surfaces of both Fluid Systems polyetherurea and Filmtec aromatic polyamide thin-film composite reverse osmosis membranes that had been operated on pretreated municipal (activated-sludge effluent) feedwater at Water Factory 21 (Orange County Water District, Fountain Valley, CA.) for a period of approximately two months.

Ten different concentrations of each biocide solution were prepared in duplicate in two-fold dilution series ranging from 1:2 to 1:1024. The diluent used was R2A broth (complex bacteriological growth medium) diluted 1:5 with the pH's adjusted appropriately for each biocide. To each tube, 5.0 ml of the biocide stock working solution was added to the first tube and two-fold dilutions were prepared from this tube. Duplicate control preparations containing no biocide were included with each dilution series.

Stock working solutions of biocides were prepared using ultrapure (18 megaohm) water and their pH's adjusted according to the following schedule. Each stock biocide solution was filter sterilized and stored in sterile plastic containers.

BIOCIDE STOCK WORKING SOLUTION	pH	BIOCIDE I.D. LABEL
Sodium Benzoate, 1.0%	5.0	A
EDTA, 1.0%	5.0	B
Sodium Benzoate/EDTA, 1.0%	5.0	C
Salicylic Acid, 0.4%	5.0	D
Sorbic Acid, 0.2%	5.0	E
Benzalkonium Chloride/EDTA, 1.0%	5.0	F
Glutaraldehyde, 6.0%	5.0	G
Benzalkonium Chloride, 1.0%	7.0	H
Substituted Isothiazolinone, 1.0%	7.0	I
Bromochlorodimethyl Hydantoin, 200 mg/l	7.0	J
Cetyltrimethylammonium p-toluene sulfonate, 0.1%	7.0	K
Sodium Bisulfite, 2.0%	7.0	L
Sodium Benzoate/Sodium Borate, 1.0%	5.5	M
Bromonitropropane diol, 1.0%	6.0	N

The biofouled reverse osmosis membranes were cut into rectangular sections measuring approximately 1- x 2-cm and a single such fragment was added to each test tube in the series (including controls). The tubes were incubated at 30°C with agitation (200 rpm) for up to 18 days. The presence (+) or absence (-) of visible turbidity, indicating growth or no growth, respectively, was recorded after four and eighteen days of incubation.

4.3 RESULTS

Results of the biocide screening tests are summarized for Filmtec and Fluid Systems membranes in Tables 5-8 and in Figures 2-4. Because some of the biofilm bacteria grew slowly, a two to three week incubation time was preferred (compared to shorter times) to obtain conclusive results. Some test tubes which were clearly negative (i.e., no visible growth) after the initial four or six day incubation period, converted to positive (i.e., visible growth) after 14-18 days incubation. Thus, a minimum 14 day incubation time will be employed in all future biocide growth-inhibition tests.

The "minimum inhibitory concentrations" (MIC values) used for the fourteen biocides tested are summarized in Tables 5-8 and Figure 2. The biocides which exhibited the greatest degree of growth inhibition included:

EDTA (1% wt./vol.) working solution)
Sodium Benzoate/EDTA mixture (1% wt./vol. each)
Benzalkonium Chloride/EDTA mixture (1% wt./vol. each)
Glutaraldehyde (6% wt./vol.)
Benzalkonium Chloride (1% wt./vol.)
Substituted Isothiazolinone (1% wt./vol.)
Cetyltrimethylammonium p-toluene sulfonate (0.1% wt./vol.)

The above agents all inhibited microbial re-growth at final dilutions of 1:256 or more.

The least effective biocides included:

Salicylic Acid (0.4% wt./vol.)
Sorbic Acid (0.2% wt./vol.)
Bromochlorodimethyl Hydantoin (200 mg/l)

Each of these agents resulted in growth inhibition only up to dilutions of 1:4. Memstore, the sodium benzoate/sodium borate mixture (1% wt./vol.), exhibited growth inhibition only up to a 1: 8 dilution.

The "molar activity" of each biocide is presented in Figures 3 and 4 (Molar activities shown in Figure 4 are log values). Molar activity was defined as the quotient of the observed MIC for a particular compound divided by the molarity of the stock solution for the same compound. Thus, the molar activity values presented in Figure 3 represent biocide activity expressed on a "per molecule" basis, thereby allowing direct comparison of activity between different biocides. Interestingly, Kathon yielded the highest molar activity followed by cetyltrimethylammonium p-toluene sulfonate, EDTA, benzalkonium chloride + EDTA, benzalkonium chloride and sodium benzoate + EDTA, respectively. The relatively high molar activity of the divalent cation chelating agent EDTA combined with its comparatively ease of handling and low environmental toxicity suggests that this compound and its many chemical analogs should be tested more thoroughly in a Phase II effort.

Interestingly, biocide activity appeared to be generally greater (higher MIC's) using the Fluid Systems polyetherurea membrane than the Filmtec polyamide membrane. The reason for this difference is not clear at this time and deserves further investigation during Phase II. It is possible that the size and/or qualitative composition (i.e., type of bacteria) of inoculum was somewhat different for the two types of RO membrane, although both membranes were operated on the same feedwater for the same amount of time (about two months) at Water Factory 21. Nevertheless, different membrane types used in this study. During the Phase II effort the amount of biofilm associated with different membrane elements will be quantified prior to using these membranes to challenge experimental biocides.

The least effective biocides included salicylic acid, sorbic acid, and bromochloradimethyl hydantoin. Each of these agents resulted in growth inhibition only up to dilutions of 1:4 or less. Memstore exhibited growth inhibition only up to a dilution on the Filmtec membrane and showed no detectable activity at any dilution on the Fluid Systems membrane.

Table 5

Raw Biocide MIC Data for FilmTec Polyamide Membrane

Biocide	Biocide Dilution Factor (+ = growth)										
	2	4	8	16	32	64	128	256	512	1024	con
A	-	-	-	+	+	+	+	+	+	+	+
	-	-	-	-	+	+	-	+	+	+	+
B	-	-	-	-	-	-	-	-	-	-	+
	-	-	-	-	-	-	-	-	-	-	+/-
C	-	-	-	-	-	-	-	-	-	+	+
	-	-	-	-	-	-	-	-	-	+	+
D	-	-	+	+	+	+	+	+	+	+	+
	-	-	+	+	+	+	+	+	+	+	NA
E	-	-	+	+	+	+	+	+	+	+	+
	-	+/-	-	+	-	-	+	+	+	+	+
F	-	-	-	-	-	-	-	-	-	-	+
	-	-	-	-	-	-	-	-	-	-	+
G	-	-	-	-	-	-	-	-	-	-	+
	-	-	-	-	-	-	-	-	-	+	+
H	-	-	-	-	-	-	-	-	-	-	+
	-	-	-	-	-	-	-	-	-	-	+/-
I	-	-	-	-	-	-	-	+	+/-	+	+
	-	-	-	-	-	-	-	+/-	-	+/-	+
J	-	+	+	+/-	+	+	+	+	+	+	+
	-	+	+	+/-	+/-	+/-	+	+	+	+	+
K	-	-	-	-	-	-	-	-	+	+	+
	-	-	-	-	-	-	-	-	+	+	+
L	-	-	-	-	+	+	+	+	+	+	+
	-	-	-	-	-	+	+	+	+	+	+
M	-	-	-	+	+	+	+	+	+	+	+
	-	-	+/-	+	+	+	NA	+	+	+	+
N	-	-	-	-	-	-	+/-	+/-	+	+	+
	-	-	-	-	-	-	+/-	+/-	+	+/-	+

Table 6

Raw Biocide MIC Data for Fluid Systems Polyetherurea Membrane

Biocide Dilution Factor (+ = growth)

Biocide	2	4	8	16	32	64	128	256	512	1024	con
A	-	-	-	+	+	+	+	+	+	+	+
	-	-	-	+	+	+	+	+	+	+	+
B	-	-	-	-	-	-	+/-	+	+	+	+
	-	-	-	-	-	-	+/-	NA	+	+	+
C	-	-	-	-	-	+	+	+	+	+	+
	-	-	-	-	-	+	+	+	+	+	+
D	-	+	+	+	+	+	+	+	+	+	+
	-	+	+	+	+	+	+	+	+	+	+
E	-	-	+	+	+	+	+	+	+	+	+
	-	-	+	+	+	+	+	+	+	+	+
F	-	-	-	-	-	-	-	-	+	+	+
	-	-	-	-	-	-	-	-	+	+	+
G	-	-	-	-	-	-	+	+	+	+	+
	-	-	-	-	-	-	+	+	+	+	+
H	-	-	-	-	-	-	-	-	+	+	+
	-	-	-	-	-	-	-	-	+	+	+
I	-	-	-	-	-	-	+	+	+	+	+
	-	-	-	-	-	-	+	+	+	+	+
J	+	+	+	+	+	+	+	+	+	+	+
	+	+	+	+	+	+	+	+	+	+	+
K	-	-	-	-	+	+	+	+	+	+	+
	-	-	-	-	+	+	+	+	+	+	+
L	-	-	-	+	+	+	+	+	+	+	+
	-	-	-	+	+	+	+	+	+	+	+
M	+	+	+	+	+	+	+	+	+	+	+
	+	+	+	+	+	+	+	+	+	+	+
N	-	-	-	-	-	+	+	-	+	+	+
	-	-	-	-	-	+	+	+	+	+	+

BIOCIDE LEGEND FOR TABLES 5 AND 6

con = control (no biocide addition)
A = Sodium Benzoate, 1%
B = EDTA, 1%
C = Sodium Benzoate/EDTA, 1%
D = Salicylic Acid, 0.4%
E = Sorbic Acid, 0.2%
F = Benzalkonium Chloride/EDTA, 1%
G = Glutaraldehyde, 6%
H = Benzalkonium Chloride, 1%
I = Kathon, 1%
J = Bromochlorodimethyl Hydantoin, 200 mg/l
K = Cetyltrimethammonium p-toluene Sulfonate, 0.1%
L = Sodium Bisulfite, 2%
M = Memstore, 1%
N = Bromonitropropanediol, 1%
NA = Not Available

Table 7

MIC Values and Molar Activities of Biocides Tested Against Filmtec Polyamide Membrane

Biocide	Stock %	Mol. Wt.	Molarity	MIC[b]	Molar Activity[c]
Na/benzoate	1.0	144.1	0.069	8	116
EDTA	1.0	372.2	0.0269	1024	38067
Na/benzoate + EDTA	1.0	258[a]	0.0388	512	13196
salicylic acid	0.4	138.12	0.2896	4	13.8
sorbic acid	0.2	112.13	0.179	2	11.2
benzalkonium/Cl + EDTA	1.0	324[a]	0.0309	1024	33139
glutaraldehyde	6.0	100.12	0.599	512	854.8
benzalkonium/Cl	1.0	276	0.0362	1024	28287
Kathon	1.0	?	?	128	?
bromochlorodi-methyl hydantoin	0.02	241	0.00083	2	2409.6
cetyltrimethylam-monium p-toluene sulfonate	0.1	455.7	0.00219	256	116895
Na/bisulfite	2.0	104	0.192	16	83.3
Memstore	1.0	?	?	4	?
Progard	80.0[d]	166	?	8	?
bromonitropropane-diol	1.0	200	0.050	64	1280

a Molecular weight shown is an average of component molecular weights.

b MIC = 'minimal inhibitory concentration', i.e., the highest biocide dilution that resulted in complete growth inhibition.

c 'Molar Activity' refers to observed biocide activity (MIC) expressed per mole of biocide. Molar activity is computed by dividing the MIC by the molarity of the stock biocide solution.

d Commercial product diluted to 80% strength for working stock. Concentration of active ingredient was unknown.

Table 8

MIC Values and Molar Activities of Biocides Tested Against Fluid System Polyetherurea Membrane

Biocide	Stock %	Mol. Wt.	Molarity	MIC[c]	Molar Activity[d]
Na/benzoate	1.0	144.1	0.069	8	116
EDTA	1.0	372.2	0.0269	64	2379
Na/benzoate+EDTA	1.0	258[a]	0.0388	32	825
salicylic acid	0.4	138.12	0.2896	2	6.9
sorbic acid	0.2	112.13	0.179	4	22.3
benzalkonium/Cl +EDTA	1.0	324[a]	0.0309	256	8285
glutaraldehyde	6.0	100.12	0.599	64	107
benzalkonium/Cl	1.0	276	0.0362	256	7072
Kathon	1.0	?	?	64	?
bromochlorodi-methyl hydantoin	0.02	241	0.00083	NA[b]	NA
cetyltrimethylam-monium p-toluene sulfonate	0.1	455.7	0.00219	16	7306
Na/bisulfite	2.0	104	0.192	8	41.7
Memstore	1.0	?	?	NA[b]	NA
Progard	80.0[e]	166	?	8	?
bromonitropropane-diol	1.0	200	0.050	32	640

a Molecular weight shown is an average of component molecular weights.

b NA = no biocide activity evident at lowest test dilution (1:2).

c MIC='minimal inhibitory concentration', i.e., the highest biocide dilution that resulted in complete growth inhibition.

d 'Molar Activity' refers to observed biocide activity (MIC) expressed per mole of biocide. Molar activity is computed by dividing the MIC by the molarity of the stock biocide solution.

e Commercial product diluted to 80% strength for working stock. Concentration of active ingredient unknown.

Biocide Effectiveness: MIC Data

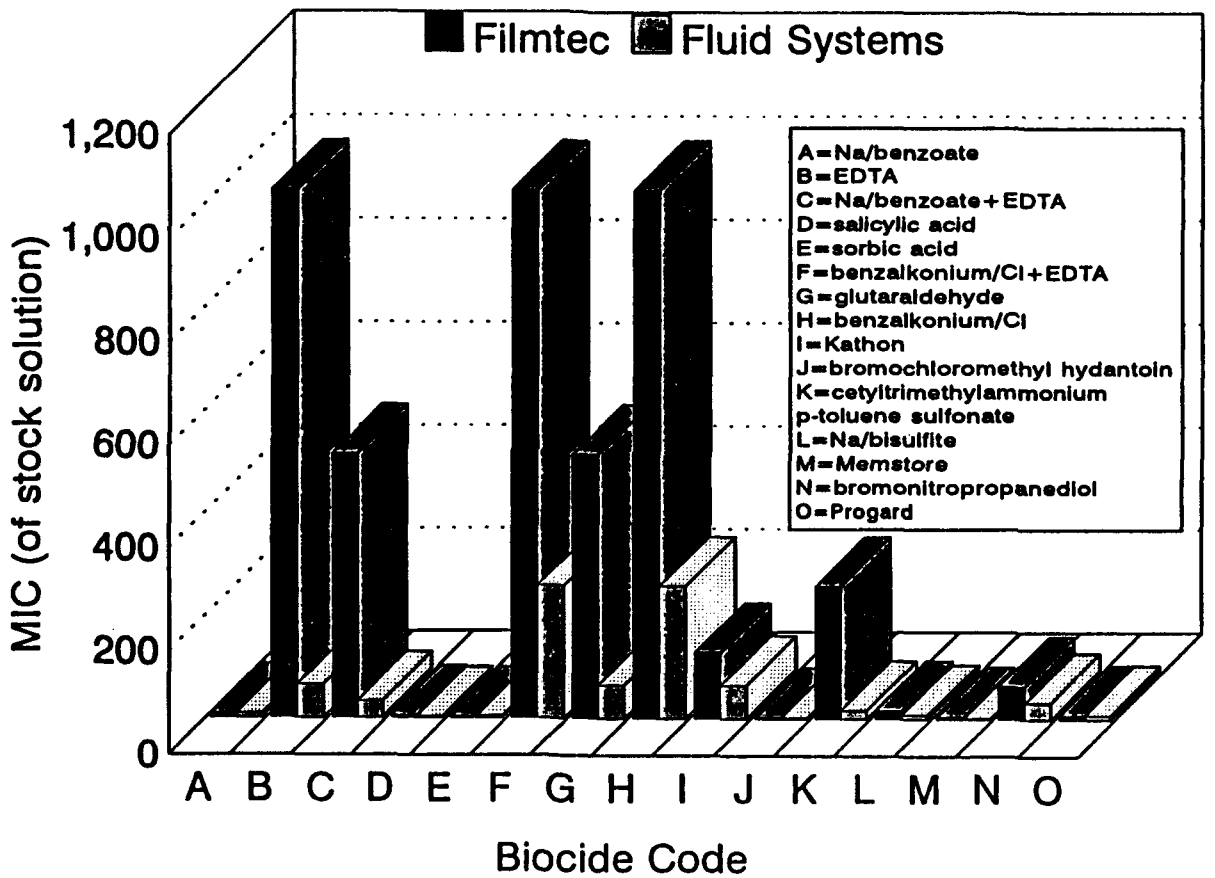

Figure 2 - MIC Values of Test Biocides

Biocide Effectiveness: Molar Activity

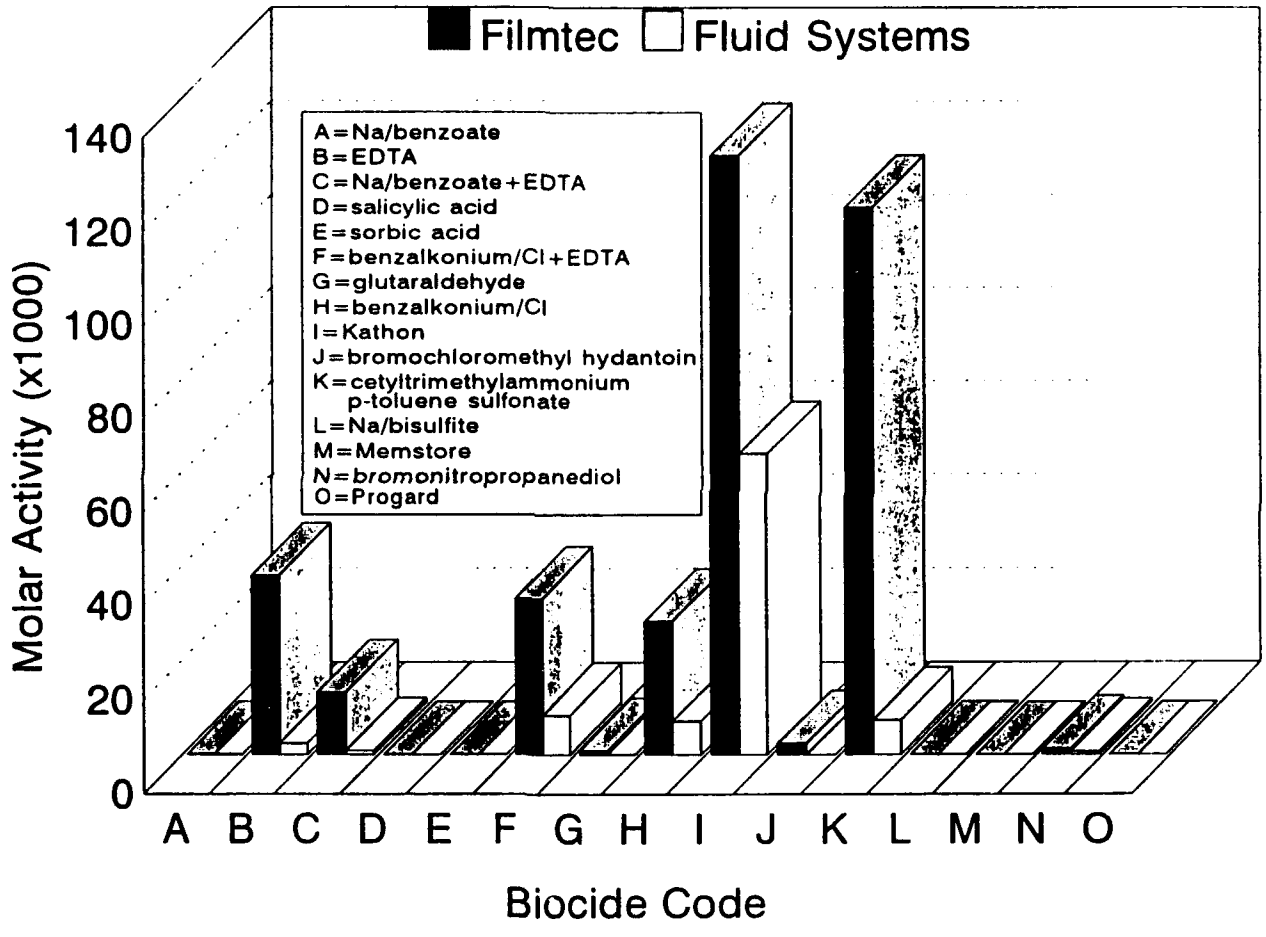

Figure 3 - Molar Activities of Biocides

Biocide Effectiveness: Molar Activity

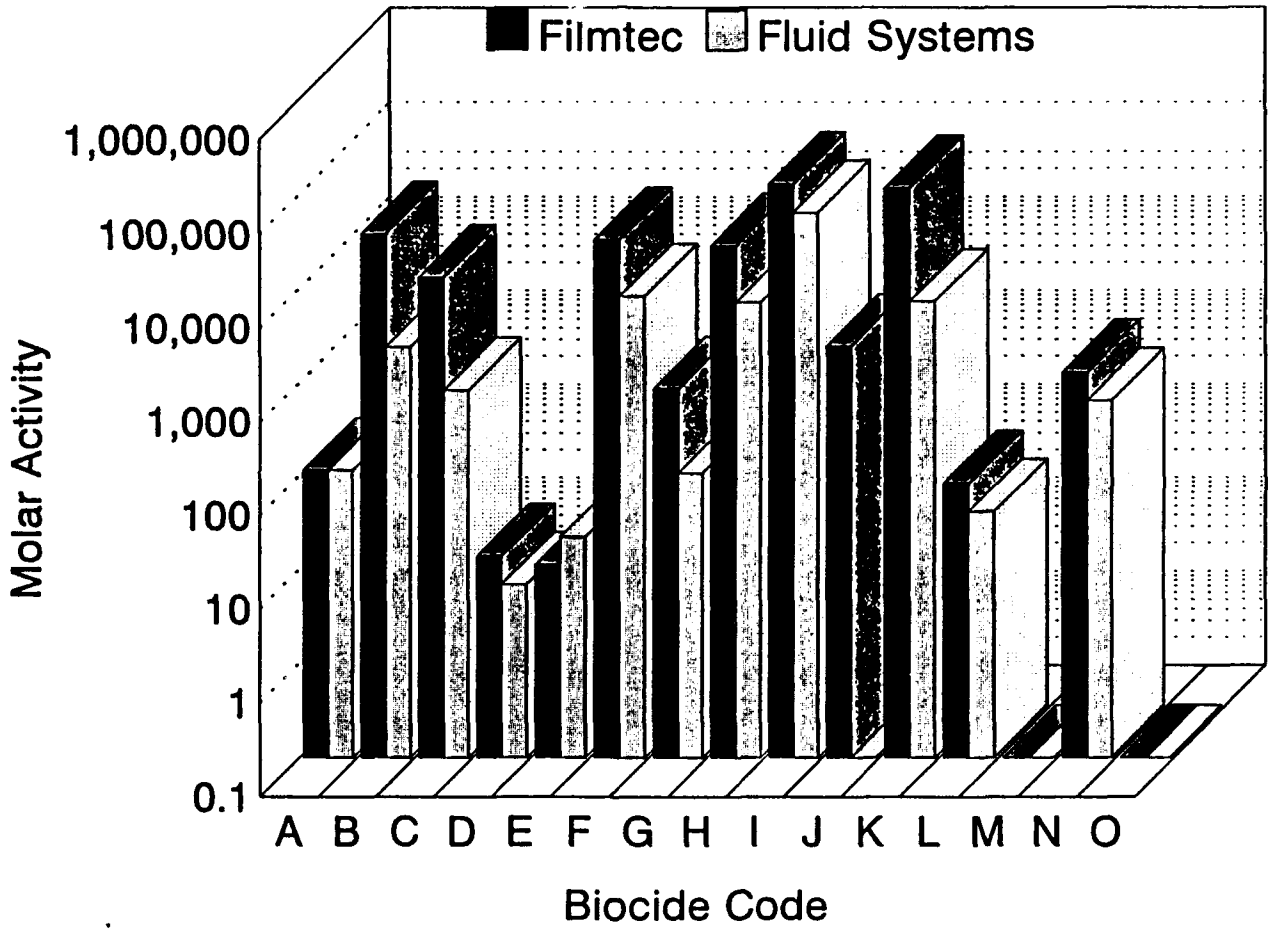

Figure 4 - Molar Activities Expressed on a Log Scale (Biocides Codes Same as in Figure 2)

5.0 SUMMARY AND CONCLUSIONS

The objectives of the six-month Phase I feasibility program were to identify existing and novel antimicrobial agents (i.e., biocides) for preservation of reverse osmosis membrane elements used in the ROWPU systems and to determine the feasibility for biocide testing and performance evaluation. These objectives were met and will provide an excellent foundation for follow-on Phase II work; the latter would be considerably more thorough and extensive.

The program focused on Fluid Systems and Filmtec thin-film composite membranes currently used in all the armed services ROWPU units. The candidate biocides selected for evaluation were based on their reported disinfection activities, known or suspected effects on reverse osmosis membrane integrity and performance, safety and environmental properties, chemical stability and shelf life, ease of handling, commercial availability and cost.

In total, sixteen candidate chemical biocide systems were evaluated at various exposure levels for biocidal effectiveness and for possible adverse effects on the transport properties of both membrane types. Several of the candidate biocide systems, particularly the ethylenediaminetetraacetic acid based systems, met all the objectives required for a biocide. That is, exert no effect on the transport properties of either membrane, chemically stable for a long shelf life, commercially available in solid form at low cost, non-toxic to humans, and environmentally acceptable. Also included among the chemical biocides, as a standard for comparison, were several commercial biocide systems. None of these systems met all of the objectives.

Gamma irradiation was also evaluated. In order to establish a sterilizing dose for the membranes, it was necessary to balance the radiation tolerance of the membranes against the dose of radiation considered necessary to establish sterility. It was demonstrated that the membranes could be radiated as levels required for complete kill without serious damage to the membranes. This method is particularly attractive for sterilizing packaged spiral-wound membrane elements , soon after manufacture, for long-term storage by the armed services. Further, it would be possible to radiate the elements in the presence of a suitable chemical biocide such as ethylenediamine-tetraacetic acid. Subsequently, the chemical biocide could be used alone for sterilization, without gamma irradiation, in the field following ROWPU operations.

Based on the success of this program, it is recommended that development of a biocide system for ROWPU membrane elements be continued on a follow-on Phase II program; the potential for success is excellent.

6.0 RECOMMENDATIONS

It is recommended that the Phase I feasibility study, described in this report, be continued. Even though the this program was very brief, i.e. six months, the study provides and excellent foundation for future development. The recommended program should be considerably more thorough and extensive and extend the evaluation of gamma irradiation, chemical biocides and methodologies for element preservation.

A follow-on program would result in a biocide for the armed services that would protect spiral-wound membrane elements from microbiological fouling and decomposition during long-term storage. The biological agents would be environmentally safe and effective at inactivating microorganisms associated with membrane surfaces without compromising membrane performance.

An overall strategic for biocide testing and evaluation is illustrated in Figure 5. A list of "potential biocides" would be compiled based upon information obtained from various sources, including Phase I results. For example, the divalent cation-chelating agents such as ethylenediaminetetraacetic acid (EDTA) and related chemical analogs appear to be a very promising group of "potential biocides" for membrane storage applications. This group, in addition to its normal chelating ability, have been found to be immune to bacteria or molds and have shown wide uses in foods, medical and pharmaceutical applications.

An excellent test for rapidly screening potential new biocides for antimicrobial activity is the swatch ("growth") test which was employed during this program. While simple in concept and execution (see Figure 6), this cost effective test did provide useful preliminary information concerning the relative effectiveness of biocidal agents in suppressing microbial growth of reverse osmosis biofilm bacteria. Thus, this test would be retained in a follow-on development program.

A second biocide screening test is based on the application of a recently discovered fluorescent redox dye that can be used to rapidly and directly (i.e., microscopically) assess the viability of bacteria comprising an attached biofilm (Figure 7). The dye is referred to as CTC (cyanditolyl tetrazolium chloride) and has been employed in recent years in studies of the electron-transport activity of Ehrlich Acsites tumor cells (Stellmach, 1984: Stellmach and Severin, 1987). Researchers in the Biotechnology Research Department at the Orange County Water District, Fountain Valley, CA. have recently employed CTC for determining the metabolic (i.e., repirometric) activity of free-living (i.e., planktonic) and surface-associated environmental bacteria. Viable bacteria are recognized in microscopic preparations by the intracellular deposition of a fluorescent insoluble CTC-formazan having an emission maximum at approximately 602 nm (excitation wavelength = 402 nm). Significantly, CTC was found to be useful

for determining cellular viability in biofilms following (formaldehyde) treatment (Figure 8).

Two kinds of reverse osmosis biofilms can be utilized in the CTC screening tests (also referred to here as the "direct microscopic method"). First, strips of previously biofouled reverse osmosis membranes are place in different biocide dilutions for various periods of time ("contact time"). Following exposure to the biocide, the strips are rinsed briefly in a dilute phosphate buffer solution and transferred to a nutrient-amended CTC solution for staining, after which red-fluorescent (i.e., actively respiring) bacteria can be enumerated microscopically using ultra-violet optics.

In an alternative approach, glass microscope slides can be coated with ultrathin films of polymer of which the membrane is composed, i.e., cellulose acetate or polyamide thin-film composite membranes(see Figure 7). The polymer coated slide are placed in a pH-buffered flow stream (recirculated) containing specific fouling bacteria (or a microbial consortium) and a surface biofilm allowed to form. The length of time allowed for biofilm formation ranges from several hours to several days depending on the biofilm thickness required. The slides are then exposed to biocide dilutions for various times, rinsed, stained with CTC to mark remaining viable bacteria and finally examined microscopically. The DNA-binding fluorochrome 2,4, diamidino-2-phenylindole (DAIP; Coleman, 1980; Porter and Feig, 1980) can also be used to counterstain the CTC-treated slides so that the "total"bacterial numbers can be quantified in the same preparations used to count viable bacteria. Using this technique, it is possible to directly enumerate not only viable (i.e., red-fluorescing respiring) bacteria, but also non-viable (blue-fluorescing) cells. Biocide effectiveness can then be expressed in terms of the percentage inactivation on a biofilm population.

In addition to chemical biocides, gamma irradiation appears very promising both alone and in combination with a chemical biocide. Gamma irradiation looks particularly promising for long-term storage. That is, sterilization of the element in it's storage container immediately after being manufactured. Gamma irradiation of membrane samples, and spiral-wound elements, should be used in conjunction with free radical scavengers to minimize membrane damage. This would allow higher radiation doses which are more effective in killing bacteria. The premise is that the membrane manufacturers would irradiate elements in the presence of a suitable biocide for the long-term element storage by the military. In addition, this biocide would be used in the field for sterilization of the elements following ROWPU operation.

Proposed Experimental Approach for Phase II

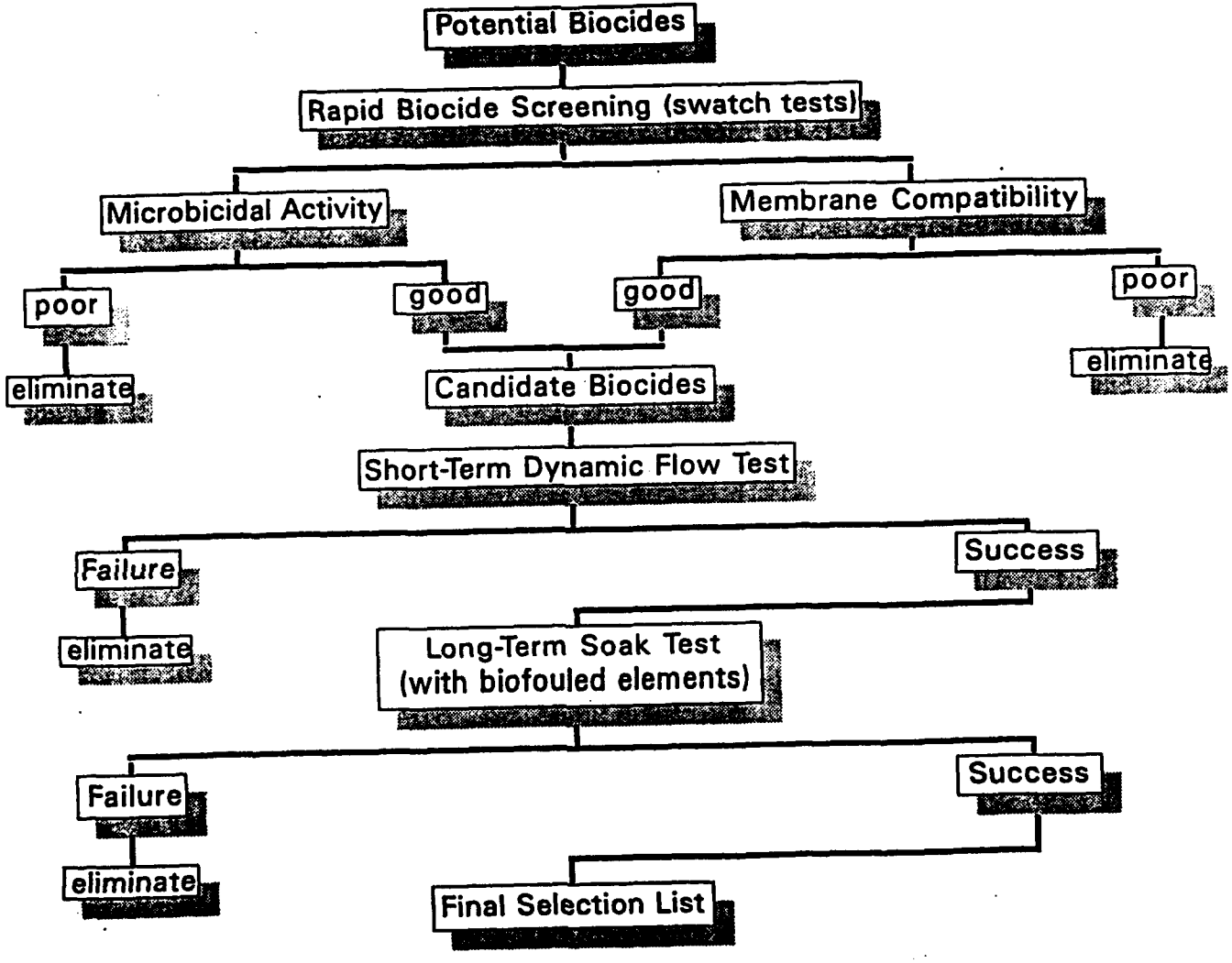

Figure 5 - Proposed Biocide Screening and Evaluation Flow Diagram (Overall Approach)

Growth Screening Method

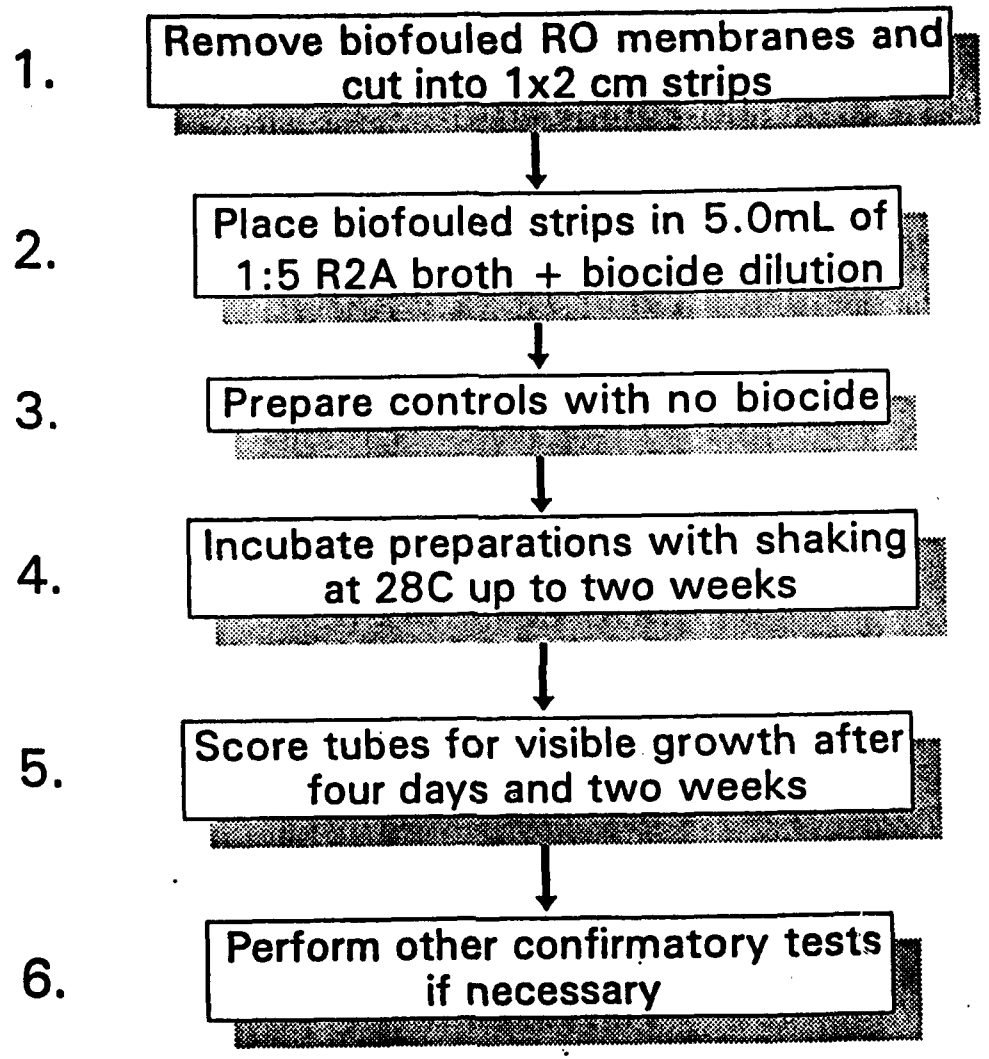

Figure 6 - "Growth Screening Method" for Determining Relative Microbicidal Effectiveness

CTC Method for Evaluating Biocides

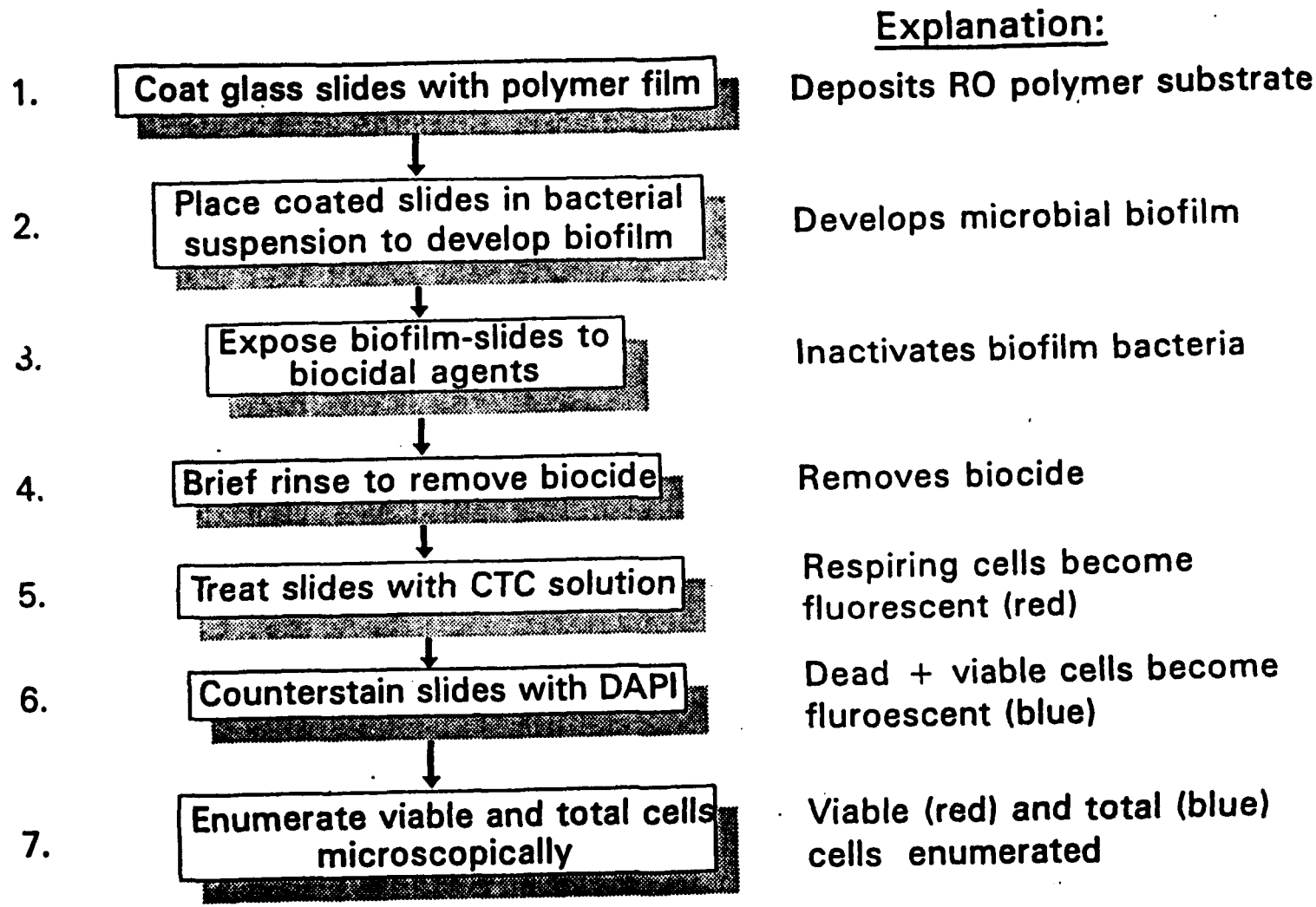

Figure 7 - Outline of "Direct CTC Microscopic Method" for Rapid Bioicide Screening

Effect of Formaldehyde on Bacterial Survival in a Marine RO Biofilm (by CTC Method)

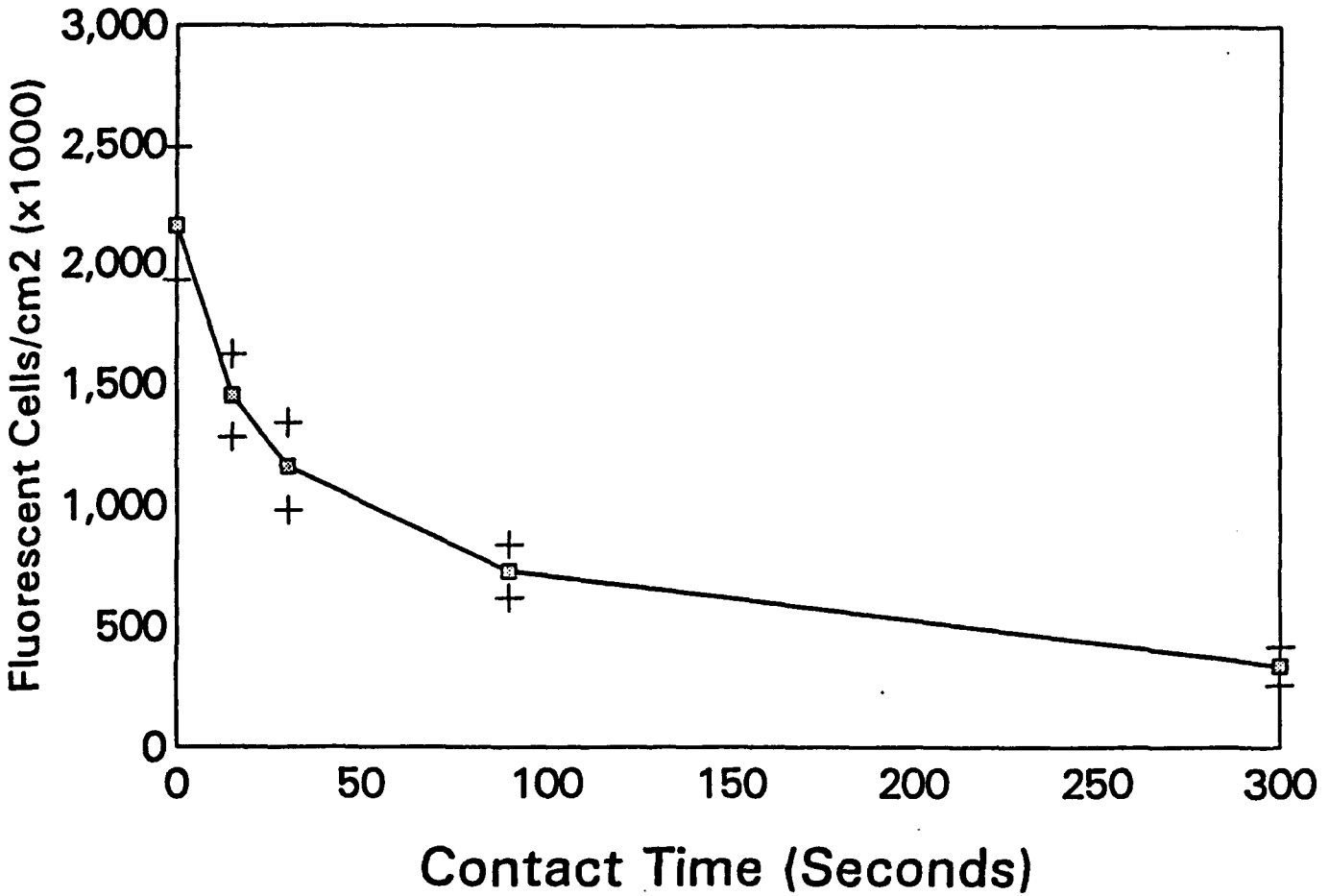

Figure 8. Ability of Formaldehyde (2.0% wt./vol.) to Inactive Bacteria Comprising a Marine Biofilm Formed on Cellulose Acetate Polymer. Viable Bacteria Determined by CTC Procedure.

7.0 REFERENCES

1. Reasoner, D.J. and E.E. Geldrich, 1987, "A New Medium for the Enumeration and Subculture of Bacteria from Potable Water", Appl. Environ. Microbiol., 47, 1-7.

2. Ridgway, H.F., 1988, "Microbial Adhesion and Biofouling of Reverse Osmosis Membranes", in Parekh, B.S. (ed.), Reverse Osmosis Technology Application for High-Purity Water Production, pp. 429-482, Marcel Dekker, Inc., New York and Basel.

3. Cheng, K. J. et al, 1981, "Autochthanous and Pathogenic Colonization of Animal Tissues by Bacteria" Can. J. Microbiol, 47, 261.

4. Coleman, A. W., 1980, "Enhanced Detection of Bacteria in Natural Environments by Fluorescent Staining of DNA", Limnol. Oceanogr. 25, 948.

5. Engelbrecht, R. S. et al, 1979, "Acid-Fast Bacteria and Yeasts as Indicators of Disinfection Efficiency", USEPA Report, Cincinnati, OH.

6. Hayes, P. S. et al, 1982, "Resistance of Mycobacterium Chelonei-Like Organisms to Formaldehyde", Appl. Environ. Microbiol. 43, 722.

7. Chavallier, M.W. et al, 1990, "Disinfecting Biofilms in a Model Distribution System", J. Amer. Water Works Assoc., 82, 87.

8. Means, E.G. et al, 1981, "Evaluating Mediums and Plating Techniques for the Enumeration of Bacteria in Water Distribution Systems", J. Amer. Water Works Assoc., 73, 585.

9. Porter, K.G. and Y.S. Feig, 1980, "The Use of DAPI for Identifying and Counting Aquatic Microflora", Limnol. Oceangr., 25, 943.

10. Reasoner, D.J. and E.E. Geldrich, 1985, "A New Medium for the Enumeration and Subculture of Bacteria from Potable Water", Appl. Environ. Microbiol., 49, 1.

11. Ridgway, H.F. et al, 1983, "Microbial Fouling of Reverse Osmosis Membranes Used in Advanced Wastewater Treatment Technology: Chemical, Bacteriological and Ultrastructural Analysis", Appl. Environ> Microbiol., 45, 1006.

12. Ridgway, H.F. et al, 1984, "Biofilm Fouling of RO Membranes - Its Nature and Effect on Treatment of Water for Reuse", J. Amer. Water Works Assoc., 76, 94.

13. Ridgway, H.F. et al, 1985, "Bacterial Adhesion and Fouling of Reverse Osmosis Membranes", J. Amer. Water Works Assoc., 77, 97.

14. Stellman, J., 1984, "Fluorescent Redox Dyes: I. Production of Fluorescent Formazon by Unstimulated and Phorbol ester or digitonin-stimulated Ehrlich Ascites Tumor Cells", Histochem. J., 80, 137.

15. Stellman, J. and E. Severin, 1987, "A Fluorescent Redox Dye: Influence of Several Substrates and Electron Carriers on the Tetrazolium Salt-Formazon Reaction of Ehrlich Ascites Tumor Cells", Histochem. J., 19, 21.

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS **TEST #** 44
ELEMENT # 3728 (SAME ELEMENT, NEW CUT)
MEMBRANE SHEET # 3728-22
MEMBRANE I.D. # 3728-44

CONTROL MEMBRANE TEST DATA BEFORE GAMMA IRRADIATION

TEST DATE: 10/3/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 33.5 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.6

START TIME: 1345
FINISH TIME: 1445
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	6.0	1.20 x 18.3 =	21.96 x	0.724 =	15.9	770	98.7
2	3	6.1	1.22 x 18.3 =	22.33 x	0.724 =	16.2	540	99.1
3	5	6.8	1.36 x 18.3 =	24.89 x	0.724 =	18.0	560	99.1
					AVG.	16.7	623	99.0

MEMBRANE TEST DATA AFTER GAMMA IRRADIATION

RADIATION DATE: __/__/ 91

RADIATION LEVEL: _____ MRADS **BUFFER:** _____ **pH:** _____

TEST DATE: 10/14/ 91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 32 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.8

START TIME: 1410
FINISH TIME: 1510
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	5.2	1.04 x 18.3 =	19.03 x	0.765 =	14.5	720	98.8
2	4	6.4	1.28 x 18.3 =	23.42 x	0.765 =	17.1	810	98.7
3	6	6.5	1.30 x 18.3 =	23.79 x	0.765 =	18.2	770	98.7
					AVG.	16.60	767	98.7

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS **TEST #** 45
ELEMENT # 3728 (SAME ELEMENT, NEW CUT)
MEMBRANE SHEET # 3728-23
MEMBRANE I.D. # 3728-45

CONTROL MEMBRANE TEST DATA BEFORE GAMMA IRRADIATION

TEST DATE: 10/3/ 91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.6

START TIME: 1220
FINISH TIME: 1320
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY:

CELL	SAMPLE	MLS	MLS / MIN		AREA CORR.		TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	1	5.6	1.12	x 18.3 =	20.50	x	0.738	=	15.1	490	99.2
2	3	5.2	1.04	x 18.3 =	19.03	x	0.738	=	14.0	570	99.1
3	5	5.2	1.04	x 18.3 =	19.03	x	0.738	=	14.0	600	99.0
								AVG.	14.4	553	99.1

MEMBRANE TEST DATA AFTER GAMMA IRRADIATION

RADIATION DATE: __/__/ 91

RADIATION LEVEL: _____ MRADS **BUFFER:** _____ **pH:** _____

TEST DATE: 10/14/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 31.5 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH:

START TIME: 1040
FINISH TIME: 1140
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS/MIN		AREA CORR.		TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	2	5.0	1.00	x 18.3 =	18.30	x	0.780	=	14.3	730	98.8
2	4	6.6	1.32	x 18.3 =	24.16	x	0.780	=	18.8	880	98.5
3	6	6.9	1.38	x 18.3 =	25.25	x	0.780	=	19.7	1100	98.2
								AVG.	17.6	903	98.5

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS TEST # 46
ELEMENT # 3728 (SAME ELEMENT, NEW CUT)
MEMBRANE SHEET # 3728-24
MEMBRANE I.D. # 3728-46

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/3/91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.6

START TIME: 1505
FINISH TIME: 1605
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY:

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	5.7	1.14 x 18.3 =	20.86 x	0.738 =	15.4	530	99.1
2	3	5.2	1.04 x 18.3 =	19.03 x	0.738 =	14.0	390	99.3
3	5	6.2	1.24 x 18.3 =	22.69 x	0.738 =	16.7	520	99.1
					AVG.	15.4	480	99.2

GAMMA RADIATION

MEMBRANE TEST DATA AFTER ~~BIOCIDE~~ EXPOSURE

BIOCIDE: N/A CONC.: N/A BUFFER: N/A pH: N/A

IMMERSION IN BIOCIDE: -/-/91
TOTAL TIME IN BIOCIDE: N/A DAYS
REMOVAL FROM BIOCIDE: -/-/91

TEST DATE: 10/14/91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 32 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.8

START TIME: 1220
FINISH TIME: 1320
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	6.5	1.30 x 18.3 =	23.79 x	0.765 =	18.2	960	98.4
2	4	6.6	1.32 x 18.3 =	24.16 x	0.765 =	18.5	800	98.7
3	6	7.2	1.44 x 18.3 =	26.35 x	0.765 =	20.1	1100	98.2
					AVG.	18.9	953	98.4

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS **TEST #** 51
ELEMENT # 3728
MEMBRANE SHEET # 3728-29
MEMBRANE I.D. # 3728-51

CONTROL MEMBRANE TEST DATA BEFORE GAMMA IRRADIATION

TEST DATE: 10/7/91
PRESSURE: 800 psi
FLOW RATE: 0.65 gpm
TEMPERATURE: 30.5 C
FEED CONDUCTIVITY: 61,000 umhos
FEED pH: 7.45

START TIME: 1020
FINISH TIME: 1120
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: A.V.D.L.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	1	5.7	1.14 x 18.3 =	20.86 x	0.810	=	16.9	700	98.9
2	3	5.6	1.12 x 18.3 =	20.50 x	0.810	=	16.6	660	98.9
3	5	5.1	1.02 x 18.3 =	18.61 x	0.810	=	15.1	460	99.2
					AVG.		16.2	607	99.0

MEMBRANE TEST DATA AFTER GAMMA IRRADIATION

RADIATION DATE: __/__/91

RADIATION LEVEL: 2.5 MRADS **BUFFER:** _____ **pH:** _____

TEST DATE: 11/1/91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 29 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.5

START TIME: 1225
FINISH TIME: 1325
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: _____

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	2	5.6	1.12 x 18.3 =	20.50 x	0.857	=	17.6	980	98.4
2	4	6.3	1.26 x 18.3 =	23.06 x	0.857	=	19.8	760	98.7
3	6	7.2	1.44 x 18.3 =	26.35 x	0.857	=	(22.6)	(1200)	—
					AVG.		18.7	870	98.5

( ) = QUANTITY NOT INCLUDED IN THE AVERAGE.

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS **TEST #** 53
ELEMENT # 3728
MEMBRANE SHEET # 3728-31
MEMBRANE I.D. # 3728-53

CONTROL MEMBRANE TEST DATA BEFORE GAMMA IRRADIATION

TEST DATE: 10/7/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 32 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.45

START TIME: 1315
FINISH TIME: 1415
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: A.V.D.L.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	6.25	1.25 x 18.3 = 22.87 x		0.765 =	17.5	560	99.1
2	3	5.8	1.16 x 18.3 = 21.23 x		0.765 =	16.2	620	99.0
3	5	7.1	1.42 x 18.3 = 25.99 x		0.765 =	19.9	710	98.8
					AVG.	17.9	630	99.0

MEMBRANE TEST DATA AFTER GAMMA IRRADIATION

RADIATION DATE: __/__/ 91

RADIATION LEVEL: 2.5 MRADS **BUFFER:** _____ **pH:** _____

TEST DATE: 11/1/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 28 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.5

START TIME: 0900
FINISH TIME: 1000
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: _____

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	7.5	— x 18.3 = — x		— =	—	1200	—
2	4	5.9	1.18 x 18.3 = 21.59 x		0.890 =	19.2	840	98.6
3	6	6.2	1.24 x 18.3 = 22.69 x		0.890 =	20.2	820	98.6
					AVG.	19.7	830	98.6

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUIDSYSTEMS **TEST #** 54
ELEMENT # 3728
MEMBRANE SHEET # 3728-32
MEMBRANE I.D. # 3728-54

CONTROL MEMBRANE TEST DATA BEFORE GAMMA IRRADIATION

TEST DATE: 10/7/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 32 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.45

START TIME: 1430
FINISH TIME: 1530
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 6.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	7.1	1.18 x 18.3 =	21.59 x	0.765 =	16.5	550	99.1
2	3	6.4	1.07 x 18.3 =	19.58 x	0.765 =	15.0	690	98.9
3	5	8.3	1.38 x 18.3 =	25.25 x	0.765 =	19.3	540	99.1
					AVG.	16.9	593	99.0

MEMBRANE TEST DATA AFTER GAMMA IRRADIATION

RADIATION DATE: __/__/ 91

RADIATION LEVEL: 2.5 MRADS **BUFFER:** _____ **pH:** _____

TEST DATE: 10/31/ 91
PRESSURE: 800 psi
FLOW RATE: 0.7 gpm
TEMPERATURE: 31 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.7

START TIME: 1425
FINISH TIME: 1525
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: _____

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	7.3	1.46 x 18.3 =	26.72 x	0.795 =	21.2	860	98.6
2	4	6.5	1.30 x 18.3 =	23.79 x	0.795 =	18.9	880	98.5
3	6	7.2	— x 18.3 =	— x	— =	—	1050	—
					AVG.	20.1	870	98.5

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS **TEST #** 58
ELEMENT # 3728
MEMBRANE SHEET # 3728-36
MEMBRANE I.D. # 3728-58

CONTROL MEMBRANE TEST DATA BEFORE GAMMA IRRADIATION

TEST DATE: 10/ 8/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 32.5 C
FEED CONDUCTIVITY: 61,000 umhos
FEED pH: 7.4

START TIME: 1240
FINISH TIME: 1340
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	1	8.2	1.64 x 18.3 =	30.01 x	0.752	=	22.6	840	98.6
2	3	8.1	1.62 x 18.3 =	29.65 x	0.752	=	22.3	700	98.9
3	5	7.6	1.52 x 18.3 =	27.82 x	0.752	=	20.9	900	98.5
					AVG.		21.9	813	98.7

MEMBRANE TEST DATA AFTER GAMMA IRRADIATION

RADIATION DATE: __/__/ 91

RADIATION LEVEL: 2.1 MRADS **BUFFER:** _____ **pH:** _____

TEST DATE: 11/18/ 91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 28.5 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: _____

START TIME: 1050
FINISH TIME: 1150
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: A.V.D.L.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	2	8.3	1.66 x 18.3 =	30.38 x	0.873	=	26.5	1900	96.7
2	4	8.1	1.62 x 18.3 =	29.65 x	0.873	=	25.9	1500	97.4
3	6	8.0	1.60 x 18.3 =	29.28 x	0.873	=	25.6	1700	97.1
					AVG.		26.0	1700	97.1

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS **TEST #** 59
ELEMENT # 3728
MEMBRANE SHEET # 3728-37
MEMBRANE I.D. # 3728-59

CONTROL MEMBRANE TEST DATA BEFORE GAMMA IRRADIATION

TEST DATE: 10/8/ 91
PRESSURE: 800 psi
FLOW RATE: 0.7 gpm
TEMPERATURE: 32 C
FEED CONDUCTIVITY: 64,000 umhos
FEED pH: 7.4

START TIME: 1420
FINISH TIME: 1520
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.

DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	7.9	1.58 x 18.3 =	28.91 x	0.7765 =	22.1	700	98.9
2	3	9.0	1.80 x 18.3 =	32.94 x	0.7765 =	25.2	750	98.8
3	5	8.0	1.60 x 18.3 =	29.28 x	0.7765 =	22.4	800	98.7
					AVG.	23.2	750	98.8

MEMBRANE TEST DATA AFTER GAMMA IRRADIATION

RADIATION DATE: __/__/ 91

RADIATION LEVEL: _____ MRADS **BUFFER:** _____ **pH:** _____

TEST DATE: 11/18/ 91
PRESSURE: 800 psi
FLOW RATE: 0.72 gpm
TEMPERATURE: 28 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 7.9

START TIME: 1300
FINISH TIME: 1400
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.

DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	8.8	1.76 x 18.3 =	32.21 x	0.890 =	28.7	1600	97.2
2	4	8.1	1.62 x 18.3 =	29.65 x	0.890 =	26.4	1700	97.1
3	6	6.7	1.34 x 18.3 =	24.52 x	0.890 =	21.8	1400	97.6
					AVG.	25.6	1567	97.3

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS **TEST #** 60
ELEMENT # 3728
MEMBRANE SHEET # 3728-38
MEMBRANE I.D. # 3728-60

CONTROL MEMBRANE TEST DATA BEFORE GAMMA IRRADIATION

TEST DATE: 10/8/91
PRESSURE: 800 psi
FLOW RATE: 0.7 gpm
TEMPERATURE: 30 C
FEED CONDUCTIVITY: 61,000 umhos
FEED pH: 7.5

START TIME: 1540
FINISH TIME: 1640
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	7.6	1.52 x 18.3 =	27.82 x	0.825 =	22.9	880	98.5
2	3	8.4	1.68 x 18.3 =	30.74 x	0.825 =	25.4	880	98.5
3	5	8.4	1.68 x 18.3 =	30.74 x	0.825 =	25.4	870	98.6
					AVG.	24.6	877	98.5

MEMBRANE TEST DATA AFTER GAMMA IRRADIATION

RADIATION DATE: __/__/ 91

RADIATION LEVEL: _____ MRADS **BUFFER:** _____ **pH:** _____

TEST DATE: 11/18/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 27 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 7.8

START TIME: 1425
FINISH TIME: 1525
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	8.5	1.70 x 18.3 =	31.11 x	0.925 =	28.8	1800	96.9
2	4	8.4	1.68 x 18.3 =	30.74 x	0.925 =	28.4	1800	96.9
3	6	7.8	1.56 x 18.3 =	28.55 x	0.925 =	26.4	1600	97.2
					AVG.	27.9	1733	97.0

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS **TEST #** 64
ELEMENT # SE3730
MEMBRANE SHEET # 3730-4
MEMBRANE I.D. # 3730-6

CONTROL MEMBRANE TEST DATA BEFORE GAMMA IRRADIATION

TEST DATE: 10/21/ 91
PRESSURE: 800 psi
FLOW RATE: 0.62 gpm
TEMPERATURE: 29.0 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 7.8

START TIME: 0900
FINISH TIME: 1000
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: A.V.D.L.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	5.9	1.18 x 18.3 =	21.59 x	0.857 =	18.5	950	98.4
2	3	6.1	1.22 x 18.3 =	22.33 x	0.857 =	19.1	920	98.4
3	5	6.4	1.28 x 18.3 =	23.42 x	0.857 =	20.1	810	98.6
					AVG.	19.2	893	98.5

MEMBRANE TEST DATA AFTER GAMMA IRRADIATION

RADIATION DATE: __/__/ 91

RADIATION LEVEL: 1.6 MRADS **BUFFER:** _____ **pH:** _____

TEST DATE: 11/19/ 91
PRESSURE: 800 psi
FLOW RATE: 0.7 gpm
TEMPERATURE: 27.5 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 8.0

START TIME: 1205
FINISH TIME: 1305
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	6.8	1.36 x 18.3 =	24.89 x	0.9075 =	22.6	1200	97.9
2	4	7.3	1.46 x 18.3 =	26.72 x	0.9075 =	24.2	1400	97.6
3	6	6.9	1.38 x 18.3 =	25.25 x	0.9075 =	22.9	1300	97.8
					AVG.	23.2	1300	97.8

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS **TEST #** 65
ELEMENT # SE 3730
MEMBRANE SHEET # 3730-5
MEMBRANE I.D. # 3730-65

CONTROL MEMBRANE TEST DATA BEFORE GAMMA IRRADIATION

TEST DATE: 10/21/ 91
PRESSURE: 800 psi
FLOW RATE: 0.7 gpm
TEMPERATURE: 29.5 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 7.6

START TIME: 1030
FINISH TIME: 1130
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.

DATA TAKEN BY: A.V.D.L.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	1	5.9	1.18 x 18.3 =	21.59 x	0.841	=	18.1	800	98.6
2	3	4.3	0.86 x 18.3 =	15.74 x	0.841	=	13.2	420	99.3
3	5	5.8	1.16 x 18.3 =	21.23 x	0.841	=	17.9	520	99.1
						AVG.	16.4	580	99.0

MEMBRANE TEST DATA AFTER GAMMA IRRADIATION

RADIATION DATE: __/__/ 91

RADIATION LEVEL: 1.6 MRADS **BUFFER:** _____ **pH:** _____

TEST DATE: 11/19/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 27 C
FEED CONDUCTIVITY: 57,000 umhos
FEED pH: 7.6

START TIME: 1035
FINISH TIME: 1135
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.

DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	2	4.7	0.94 x 18.3 =	17.20 x	0.925	=	15.9	740	98.7
2	4	6.5	1.30 x 18.3 =	23.79 x	0.925	=	22.0	900	98.4
3	6	5.5	1.10 x 18.3 =	20.13 x	0.925	=	18.6	800	98.6
						AVG.	18.8	813	98.6

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS **TEST #** 67
ELEMENT # SE 3730
MEMBRANE SHEET # 3730-7
MEMBRANE I.D. # 3730-67

CONTROL MEMBRANE TEST DATA BEFORE GAMMA IRRADIATION

TEST DATE: 10/21/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 31 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 7.6

START TIME: 1313
FINISH TIME: 1413
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY:

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	1	6.4	1.28 x 18.3 =	23.42 x	0.795	=	18.6	870	98.5
2	3	6.4	1.28 x 18.3 =	23.42 x	0.795	=	18.6	770	98.7
3	5	6.3	1.26 x 18.3 =	23.06 x	0.795	=	18.3	750	98.7
					AVG.		18.5	797	98.6

MEMBRANE TEST DATA AFTER GAMMA IRRADIATION

RADIATION DATE: __/__/ 91

RADIATION LEVEL: 1.6 MRADS **BUFFER:** _____ **pH:** _____

TEST DATE: 11/19/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 28 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 8.0

START TIME: 1325
FINISH TIME: 1425
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	2	6.6	1.32 x 18.3 =	24.15 x	0.890	=	21.5	1200	97.9
2	4	7.2	1.44 x 18.3 =	26.35 x	0.890	=	23.5	1300	97.7
3	6	7.1	1.42 x 18.3 =	25.99 x	0.890	=	23.1	1400	97.6
					AVG.		22.7	1300	97.7

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC **TEST #** 44
ELEMENT # A1318722 (2.5" ELEMENT)
MEMBRANE SHEET # 8722-14T
MEMBRANE I.D. # 8722-44

CONTROL MEMBRANE TEST DATA BEFORE GAMMA IRRADIATION

TEST DATE: 9/30/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.6

START TIME: 1215
FINISH TIME: 1315
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.

DATA TAKEN BY: A.V.D.L.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	7.8	1.56 x 18.3 =	28.55 x	0.840 =	24.0	560	99.1
2	3	8.3	1.66 x 18.3 =	30.38 x	0.840 =	25.5	480	99.2
3	5	8.2	1.64 x 18.3 =	30.01 x	0.840 =	25.2	620	99.0
					AVG.	24.9	553	99.1

MEMBRANE TEST DATA AFTER GAMMA IRRADIATION

RADIATION DATE: __/__/ 91

RADIATION LEVEL: _____ MRADS **BUFFER:** _____ **pH:** _____

TEST DATE: 10/14/ 91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 31 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.8

START TIME: 0920
FINISH TIME: 1020
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.

DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	5.5	1.10 x 18.3 =	20.13 x	0.860 =	17.3	430	99.3
2	4	5.3	1.06 x 18.3 =	19.40 x	0.860 =	16.7	450	99.3
3	6	5.3	1.06 x 18.3 =	19.40 x	0.860 =	16.7	480	99.2
					AVG.	16.9	453	99.3

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC **TEST #** 45
ELEMENT # A1318722 (2.5" ELEMENT)
MEMBRANE SHEET # 8722-146
MEMBRANE I.D. # 8722-45

CONTROL MEMBRANE TEST DATA BEFORE GAMMA IRRADIATION

TEST DATE: 9/30/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.6

START TIME: 1330
FINISH TIME: 1430
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: A.V.D.L.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	8.2	1.64 x 18.3 = 30.01	x 0.840	=	25.2	610	99.0
2	3	8.3	1.66 x 18.3 = 30.38	x 0.840	=	25.5	440	99.3
3	5	8.2	1.64 x 18.3 = 30.01	x 0.840	=	25.2	480	99.2
					AVG.	25.3	510	99.2

MEMBRANE TEST DATA AFTER GAMMA IRRADIATION

RADIATION DATE: __/__/ 91

RADIATION LEVEL: _____ MRADS **BUFFER:** _____ **pH:** _____

TEST DATE: 10/14/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 31 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.8

START TIME: 1525
FINISH TIME: 1625
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	5.8	1.16 x 18.3 = 21.23	x 0.860	=	18.3	720	98.8
2	4	5.7	1.14 x 18.3 = 20.86	x 0.860	=	17.9	650	98.9
3	6	5.4	1.08 x 18.3 = 19.76	x 0.860	=	17.0	530	99.1
					AVG.	17.7	633	98.9

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC **TEST #** 46
ELEMENT # A1318722 (2.5" ELEMENT)
MEMBRANE SHEET # 8722-15T
MEMBRANE I.D. # 8722-46

CONTROL MEMBRANE TEST DATA BEFORE GAMMA IRRADIATION

TEST DATE: 9/30/ 91
PRESSURE: 800 psi
FLOW RATE: 0.7 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.6

START TIME: 1450
FINISH TIME: 1620
ELAPSED TIME: 1.5 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	1	8.3	1.66 x 18.3 =	30.38x	0.840	=	25.5	770	98.7
2	3	8.5	1.70 x 18.3 =	31.11x	0.840	=	26.1	360	99.4
3	5	7.9	1.58 x 18.3 =	28.91x	0.840	=	24.3	580	99.0
					AVG.		25.3	570	99.0

MEMBRANE TEST DATA AFTER GAMMA IRRADIATION

RADIATION DATE: __/__/ 91

RADIATION LEVEL: _____ MRADS **BUFFER:** _____ **pH:** _____

TEST DATE: 10/15/ 91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 31 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.6

START TIME: 0825
FINISH TIME: 0925
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	2	5.4	1.08 x 18.3 =	19.76x	0.860	=	17.0	550	99.1
2	4	5.3	1.06 x 18.3 =	19.40x	0.860	=	16.7	700	98.8
3	6	4.8	0.96 x 18.3 =	17.57x	0.860	=	15.1	410	99.3
					AVG.		16.3	553	99.1

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC **TEST #** 53
ELEMENT # A1318722
MEMBRANE SHEET # 8722-20
MEMBRANE I.D. # 8722-53

CONTROL MEMBRANE TEST DATA BEFORE GAMMA IRRADIATION

TEST DATE: 10/10/ 91
PRESSURE: 800 psi
FLOW RATE: 0.7 gpm
TEMPERATURE: 32 C
FEED CONDUCTIVITY: 61,000 umhos
FEED pH: 7.4

START TIME: 1410
FINISH TIME: 1510
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	7.3	1.46 x 18.3 =	26.72 x	0.765 =	20.4	540	99.1
2	3	7.2	1.44 x 18.3 =	26.35 x	0.765 =	20.1	540	99.1
3	5	7.0	1.40 x 18.3 =	25.62 x	0.765 =	19.6	740	98.8
					AVG.	20.0	607	99.0

MEMBRANE TEST DATA AFTER GAMMA IRRADIATION

RADIATION DATE: __/__/ 91

RADIATION LEVEL: 2.5 MRADS **BUFFER:** _____ **pH:** _____

TEST DATE: 11/1/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 29 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.5

START TIME: 1350
FINISH TIME: 1450
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: _____

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	6.4	1.28 x 18.3 =	23.42 x	0.880 =	20.6	790	98.7
2	4	6.1	1.22 x 18.3 =	22.33 x	0.880 =	19.7	840	98.6
3	6	6.6	1.32 x 18.3 =	24.15 x	0.880 =	21.3	720	98.8
					AVG.	20.5	783	98.7

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC **TEST #** 54
ELEMENT # A1318722
MEMBRANE SHEET # 8722-21
MEMBRANE I.D. # 8722-54

CONTROL MEMBRANE TEST DATA BEFORE GAMMA IRRADIATION

TEST DATE: 10/10/ 91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 32 C
FEED CONDUCTIVITY: 61,000 umhos
FEED pH: 7.4

START TIME: 1535
FINISH TIME: 1635
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	1	7.5	1.50 x 18.3 =	27.45 x	0.7665	=	21.0	840	98.6
2	3	7.1	1.42 x 18.3 =	25.99 x	0.7665	=	19.9	700	98.9
3	5	7.3	1.46 x 18.3 =	26.72 x	0.7665	=	20.4	580	99.0
					AVG.		20.4	707	98.8

MEMBRANE TEST DATA AFTER GAMMA IRRADIATION

RADIATION DATE: __/__/ 91

RADIATION LEVEL: 2.5 MRADS **BUFFER:** _____ **pH:** _____

TEST DATE: 11/1/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 29 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.5

START TIME: 1518
FINISH TIME: 1638
ELAPSED TIME: 1.25 hr.
COLLECTION TIME: 7.0 min.
DATA TAKEN BY: _____

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	2	9.2	1.31 x 18.3 =	23.97 x	0.880	=	21.1	480	99.2
2	4	8.8	1.26 x 18.3 =	23.06 x	0.880	=	20.3	680	98.9
3	6	9.2	— x 18.3 =	— x	—	=	—	1400	—
					AVG.		20.7	580	99.1

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC **TEST #** 55
ELEMENT # A1392165
MEMBRANE SHEET # 2165-1
MEMBRANE I.D. # 2165-55

CONTROL MEMBRANE TEST DATA BEFORE GAMMA IRRADIATION

TEST DATE: 10/11/91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 30.5 C
FEED CONDUCTIVITY: 62,000 umhos
FEED pH: 7.7

START TIME: 0845
FINISH TIME: 0945
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	7.9	1.58 x 18.3 = 28.91	x 0.810 =		(23.4)	(2500)	—
2	3	7.7	1.54 x 18.3 = 28.18	x 0.810 =		22.8	530	99.1
3	5	7.6	1.52 x 18.3 = 27.82	x 0.810 =		22.5	510	99.2
					AVG.	22.7	520	99.1

MEMBRANE TEST DATA AFTER GAMMA IRRADIATION

RADIATION DATE: __/__/91

RADIATION LEVEL: 2.5 MRADS **BUFFER:** _____ **pH:** _____

TEST DATE: 11/4/91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 30 C
FEED CONDUCTIVITY: 59,000 umhos
FEED pH: 7.9

START TIME: 0940
FINISH TIME: 1040
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: _____

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	6.4	1.28 x 18.3 = 23.42	x 0.870 =		20.4	680	98.8
2	4	6.3	1.26 x 18.3 = 23.06	x 0.870 =		20.1	700	98.8
3	6	6.6	1.32 x 18.3 = 24.16	x 0.870 =		21.0	580	99.0
					AVG.	20.5	653	98.9

( ) = QUANTITY NOT INCLUDED IN THE AVERAGE.

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC **TEST #** 59
ELEMENT # A1392165
MEMBRANE SHEET # 2165-5
MEMBRANE I.D. # 2165-59

CONTROL MEMBRANE TEST DATA BEFORE GAMMA IRRADIATION

TEST DATE: 10/15/ 91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 32 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.6

START TIME: 1140
FINISH TIME: 1240
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	6.8	1.36 x 18.3 = 24.89 x	0.850	=	21.1	390	99.3
2	3	7.0	1.40 x 18.3 = 25.62 x	0.850	=	21.8	370	99.4
3	5	7.0	1.40 x 18.3 = 25.62 x	0.850	=	21.8	560	99.1
					AVG.	21.6	440	99.3

MEMBRANE TEST DATA AFTER GAMMA IRRADIATION

RADIATION DATE: __/__/ 91

RADIATION LEVEL: 2.1 MRADS **BUFFER:** _____ **pH:** _____

TEST DATE: 11/18/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 28.5 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 8.0

START TIME: 0920
FINISH TIME: 1020
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	5.5	1.10 x 18.3 = 20.13 x	0.895	=	18.0	780	98.7
2	4	5.4	1.08 x 18.3 = 19.76 x	0.895	=	17.7	670	98.8
3	6	5.4	1.08 x 18.3 = 19.76 x	0.895	=	17.7	740	98.7
					AVG.	17.8	730	98.7

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC **TEST #** 60
ELEMENT # A1392165
MEMBRANE SHEET # 2165-6
MEMBRANE I.D. # 2165-60

CONTROL MEMBRANE TEST DATA BEFORE GAMMA IRRADIATION

TEST DATE: 10/18/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 30 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.6

START TIME: 1555
FINISH TIME: 1655
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	7.3	1.46 x 18.3 = 26.72 x	0.850 =		22.7	410	99.3
2	3	7.3	1.46 x 18.3 = 26.72 x	0.850 =		22.7	300	99.5
3	5	7.1	1.42 x 18.3 = 25.99 x	0.850 =		22.1	470	99.2
					AVG.	22.5	393	99.3

MEMBRANE TEST DATA AFTER GAMMA IRRADIATION

RADIATION DATE: __/__/ 91

RADIATION LEVEL: 2.0 MRADS **BUFFER:** _____ **pH:** _____

TEST DATE: 11/12/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 28.5 C
FEED CONDUCTIVITY: 59,000 umhos
FEED pH: 7.9

START TIME: 1515
FINISH TIME: 1615
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: _____

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	6.6	1.32 x 18.3 = 24.16 x	0.895 =		21.6	460	99.2
2	4	6.6	1.32 x 18.3 = 24.16 x	0.895 =		21.6	520	99.1
3	6	6.8	1.36 x 18.3 = 24.89 x	0.895 =		22.3	560	99.1
					AVG.	21.8	513	99.1

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC **TEST #** 61
ELEMENT # A1392165
MEMBRANE SHEET # 2165-7
MEMBRANE I.D. # 2165-61

CONTROL MEMBRANE TEST DATA BEFORE GAMMA IRRADIATION

TEST DATE: 10/22/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 30 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.4

START TIME: 0830
FINISH TIME: 0930
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	7.5	1.50 x 18.3 =	27.45 x	0.870 =	23.9	500	99.2
2	3	7.3	1.46 x 18.3 =	26.72 x	0.870 =	23.2	420	99.3
3	5	7.3	1.46 x 18.3 =	26.72 x	0.870 =	23.2	540	99.1
					AVG.	23.4	487	99.2

MEMBRANE TEST DATA AFTER GAMMA IRRADIATION

RADIATION DATE: __/__/ 91

RADIATION LEVEL: _____ MRADS **BUFFER:** _____ **pH:** _____

TEST DATE: 11/4/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 30 C
FEED CONDUCTIVITY: 59,000 umhos
FEED pH: 7.9

START TIME: 1108
FINISH TIME: 1208
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 7.0 min.
DATA TAKEN BY: _____

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	7.6	1.09 x 18.3 =	19.95 x	0.870 =	17.3	650	98.9
2	4	7.8	1.11 x 18.3 =	20.31 x	0.870 =	17.7	780	98.7
3	6	7.9	1.13 x 18.3 =	20.68 x	0.870 =	18.0	880	98.5
					AVG.	17.7	770	98.7

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC **TEST #** 64
ELEMENT # A1392165
MEMBRANE SHEET # 2165-10
MEMBRANE I.D. # 2165-64

CONTROL MEMBRANE TEST DATA BEFORE GAMMA IRRADIATION

TEST DATE: 10/22/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 31.5 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.4

START TIME: 1225
FINISH TIME: 1325
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	6.8	1.36 x 18.3 = 24.89 x		0.855 =	21.3	350	99.4
2	3	7.1	1.42 x 18.3 = 25.99 x		0.855 =	22.2	360	99.4
3	5	6.9	1.38 x 18.3 = 25.25 x		0.855 =	21.6	350	99.4
					AVG.	21.7	353	99.4

MEMBRANE TEST DATA AFTER GAMMA IRRADIATION

RADIATION DATE: __/__/ 91

RADIATION LEVEL: 1.6 MRADS **BUFFER:** _____ **pH:** _____

TEST DATE: 11/19/ 91
PRESSURE: 800 psi
FLOW RATE: 0.75 gpm
TEMPERATURE: 27.7 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 8.0

START TIME: 1455
FINISH TIME: 1555
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	5.8	1.16 x 18.3 = 21.23 x		0.919 =	19.5	360	99.4
2	4	5.9	1.18 x 18.3 = 21.59 x		0.919 =	19.8	300	99.5
3	6	6.0	1.20 x 18.3 = 21.96 x		0.919 =	20.2	460	99.2
					AVG.	19.8	373	99.4

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC **TEST #** 606
ELEMENT # A1392165
MEMBRANE SHEET # 2165-12
MEMBRANE I.D. # 2165-606

CONTROL MEMBRANE TEST DATA BEFORE GAMMA IRRADIATION

TEST DATE: 10/22/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 31.5 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.4

START TIME: 1525
FINISH TIME: 1625
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1*	7.6	1.52 x 18.3 =	27.82 x	0.855 =	23.8	630	98.9
2	3*	6.7	1.34 x 18.3 =	24.52 x	0.855 =	21.0	500	99.2
3	5*	6.6	1.32 x 18.3 =	24.16 x	0.855 =	20.7	480	99.2
					AVG.	21.8	537	99.1

MEMBRANE TEST DATA AFTER GAMMA IRRADIATION

RADIATION DATE: __/__/ 91

RADIATION LEVEL: 1.6 MRADS **BUFFER:** _____ **pH:** _____

TEST DATE: 11/20 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 26 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 8.0

START TIME: 0945
FINISH TIME: 1045
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: _____

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2*	6.2	1.24 x 18.3 =	22.68 x	0.970 =	22.0	760	98.7
2	4*	5.8	1.16 x 18.3 =	21.23 x	0.970 =	20.6	580	99.0
3	6*	5.7	1.14 x 18.3 =	20.86 x	0.970 =	20.2	650	98.9
					AVG.	20.9	663	98.9

* COMPOSITE OF TESTS 2165-62, 63, AND 64 FOR RADIATION STUDY.

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC **TEST #** 67
ELEMENT # A1392165
MEMBRANE SHEET # 2165-13
MEMBRANE I.D. # 2165-67

CONTROL MEMBRANE TEST DATA BEFORE GAMMA IRRADIATION

TEST DATE: 10/23/ 91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 30.5 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.2

START TIME: 1110
FINISH TIME: 1210
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1*	7.0	1.40 x 18.3 =	25.62 x	0.865 =	22.2	520	99.1
2	3*	7.4	1.48 x 18.3 =	27.08 x	0.865 =	23.4	670	98.9
3	5*	7.7	1.54 x 18.3 =	28.18 x	0.865 =	24.4	710	98.8
					AVG.	23.3	633	98.9

MEMBRANE TEST DATA AFTER GAMMA IRRADIATION

RADIATION DATE: __/__/ 91

RADIATION LEVEL: 1.6 MRADS **BUFFER:** _____ **pH:** _____

TEST DATE: 11/20/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 27 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 8.0

START TIME: 1055
FINISH TIME: 1155
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: _____

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2*	5.9	1.18 x 18.3 =	21.59 x	0.940 =	20.3	640	98.9
2	4*	5.8	1.16 x 18.3 =	21.23 x	0.940 =	19.9	800	98.6
3	6*	5.6	1.12 x 18.3 =	20.50 x	0.940 =	19.3	870	98.5
					AVG.	19.8	770	98.7

*COMPOSITE OF TESTS 2165-56, 57 AND 58.

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS TEST # 1
ELEMENT # 3728
MEMBRANE SHEET # 3728-1T
MEMBRANE I.D. # 3728-1

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/12/ 91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 32 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 7.7

START TIME: 0940
FINISH TIME: 1040
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	8.7	1.74 x 18.3 = 31.84 x		0.820 =	26.1	780	98.7
2	3	8.5	1.70 x 18.3 = 31.11 x		0.820 =	25.5	620	98.9
3	5	9.0	1.80 x 18.3 = 32.94 x		0.820 =	27.0	720	98.7
					AVG.	26.2	707	98.8

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: BENZALKONIUM CHLORIDE CONC.: 0.5% BUFFER: HCl/NaHCO3 pH: 6.85

IMMERSION IN BIOCIDE: 9/26/ 91
TOTAL TIME IN BIOCIDE: 67 DAYS
REMOVAL FROM BIOCIDE: 12/2/91

TEST DATE: 12/2/ 91
PRESSURE: 800 psi
FLOW RATE: 0.61 gpm
TEMPERATURE: 26 C
FEED CONDUCTIVITY: 56,000 umhos
FEED pH: 7.8

START TIME: 0930
FINISH TIME: 1030
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: A.V.D.L.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	—	— x 18.3 = — x		— =	—	—	—
2	4	7.8	1.56 x 18.3 = 28.55 x		0.962 =	27.5	1800	96.8
3	6	8.1	1.62 x 18.3 = 29.65 x		0.962 =	28.5	1600	97.1
					AVG.	28.0	1700	96.9

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS **TEST #** 2
ELEMENT # 3728
MEMBRANE SHEET # 3728-18
MEMBRANE I.D. # 3728-2

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/12/ 91
PRESSURE: 800 psi
FLOW RATE: 0.63 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 7.7

START TIME: 1135
FINISH TIME: 1235
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 6.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	6.4	1.07 x 18.3 =	19.58 x	0.790 =	15.5	350	99.4
2	3	8.7	1.45 x 18.3 =	26.53 x	0.790 =	20.9	370	99.4
3	5	8.2	1.37 x 18.3 =	25.07 x	0.790 =	19.8	530	99.1
					AVG.	18.7	417	99.3

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: BENZALKONIUM CHLORIDE **CONC.:** 0.1% **BUFFER:** $HCl/NaHCO_3$ **pH:** 7.3

IMMERSION IN BIOCIDE: 9/26/ 91
TOTAL TIME IN BIOCIDE: _____ DAYS
REMOVAL FROM BIOCIDE: 12/2/91

TEST DATE: 12/2/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 26.0 C
FEED CONDUCTIVITY: 56,000 umhos
FEED pH: 7.8

START TIME: 1255
FINISH TIME: 1355
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: A.V.D.L.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	4.4	0.88 x 18.3 =	16.10 x	0.962 =	15.5	770	98.6
2	4	4.5	0.90 x 18.3 =	16.47 x	0.962 =	15.8	740	98.7
3	6	5.2	1.04 x 18.3 =	19.03 x	0.962 =	18.3	900	98.4
					AVG.	16.5	803	98.6

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS **TEST #** 3
ELEMENT # 3728
MEMBRANE SHEET # 3728-2T
MEMBRANE I.D. # 3728-3

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/12/ 91
PRESSURE: 800 psi
FLOW RATE: 0.65 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 7.7

START TIME: 1430
FINISH TIME: 1530
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	9.1	1.82 x 18.3 =	33.31 x	0.780 =	26.0	800	98.6
2	3	8.7	1.74 x 18.3 =	31.84 x	0.780 =	24.8	610	98.9
3	5	9.2	1.84 x 18.3 =	33.67 x	0.780 =	26.3	820	98.6
					AVG.	25.7	743	98.7

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: BENZALKONIUM CHLORIDE **CONC.:** 0.01% **BUFFER:** $HCl/NaHCO_3$ **pH:** 6.80

IMMERSION IN BIOCIDE: 9/26/ 91
TOTAL TIME IN BIOCIDE: 68 DAYS
REMOVAL FROM BIOCIDE: 12/3/91

TEST DATE: 12/3/ 91
PRESSURE: 800 psi
FLOW RATE: 0.62 gpm
TEMPERATURE: 26.0 C
FEED CONDUCTIVITY: 56,000 umhos
FEED pH: 7.8

START TIME: 0910
FINISH TIME: 1010
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	7.0	1.40 x 18.3 =	25.62 x	0.962 =	24.6	1200	97.9
2	4*	6.9	1.38 x 18.3 =	25.25 x	0.962 =	24.3	1100	98.0
3	6*	6.9	1.38 x 18.3 =	25.25 x	0.962 =	24.3	940	98.3
					AVG.	24.4	1080	98.1

* SLIGHT GROWTH ON FABRIC SIDE OF SAMPLES.

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS **TEST #** 4
ELEMENT # 3728
MEMBRANE SHEET # 3728-2B
MEMBRANE I.D. # 3728-4

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/12/ 91
PRESSURE: 800 psi
FLOW RATE: 0.63 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 7.8

START TIME: 1555
FINISH TIME: 1700
ELAPSED TIME: 1.08 hr.
COLLECTION TIME: 6.0 min.
DATA TAKEN BY:

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	8.7	1.45 x 18.3 = 26.53	x 0.79	=	20.9	460	99.2
2	3	—	— x 18.3 = —	x —	=	—	—	—
3	5	7.8	1.30 x 18.3 = 23.79	x 0.79	=	18.8	380	99.3
					AVG.	19.9	420	99.3

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: MEMSTORE **CONC.:** 2% **BUFFER:** NONE **pH:** 5.50

IMMERSION IN BIOCIDE: 9/26/ 91
TOTAL TIME IN BIOCIDE: 68 DAYS
REMOVAL FROM BIOCIDE: 12/3/91

TEST DATE: 12/3/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 26.5 C
FEED CONDUCTIVITY: 56,000 umhos
FEED pH: 7.8

START TIME: 1300
FINISH TIME: 1400
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	4.6	0.92 x 18.3 = 16.84	x 0.943	=	15.9	760	98.6
2	4	6.0	1.20 x 18.3 = 21.96	x 0.943	=	20.7	580	99.0
3	6	4.1	0.82 x 18.3 = 15.01	x 0.943	=	14.1	620	98.9
					AVG.	16.9	653	98.8

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS **TEST #** 5
ELEMENT # 3728
MEMBRANE SHEET # 3728-2-1T
MEMBRANE I.D. # 3728-5

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/13/ 91
PRESSURE: 800 psi
FLOW RATE: 0.616 gpm
TEMPERATURE: 32.5 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 7.7

START TIME: 1345
FINISH TIME: 1445
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY:

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	1	8.9	1.78 x 18.3 =	32.57x	0.751	=	26.7	570	99.0
2	3	9.7	1.94 x 18.3 =	35.50x	0.751	=	26.7	670	98.8
3	5	9.5	1.90 x 18.3 =	34.77x	0.751	=	26.1	810	98.6
						AVG.	26.5	683	98.8

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: PROGARD **CONC.:** 20% **BUFFER:** NONE **pH:** 5.3

IMMERSION IN BIOCIDE: 9/26/ 91
TOTAL TIME IN BIOCIDE: 68 DAYS
REMOVAL FROM BIOCIDE: 12/3/91

TEST DATE: 12/3/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 26.5 C
FEED CONDUCTIVITY: 56,000 umhos
FEED pH: 7.8

START TIME: 1550
FINISH TIME: 1650
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	2	7.8	1.56 x 18.3 =	28.55x	0.943	=	26.9	680	98.8
2	4	8.0	1.60 x 18.3 =	29.28x	0.943	=	27.6	1060	98.8
3	6	8.2	1.64 x 18.3 =	30.01x	0.943	=	28.3	790	98.6
						AVG.	27.6	710	98.7

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS **TEST #** 6
ELEMENT # 3728
MEMBRANE SHEET # 3728-2-18
MEMBRANE I.D. # 3728-6

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/13/91
PRESSURE: 800 psi
FLOW RATE: 0.60 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 7.7

START TIME: 1510
FINISH TIME: 1610
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY:

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	8.3	1.66 x 18.3 =	30.38 x	0.738 =	22.4	760	98.7
2	3	9.2	1.84 x 18.3 =	33.67 x	0.738 =	24.8	710	98.8
3	5	9.0	1.80 x 18.3 =	32.94 x	0.738 =	24.3	820	98.6
					AVG.	23.8	763	98.7

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SUBSTITUTED ISOTHIAZOLINONE **CONC.:** 0.50% **BUFFER:** HCl/NaHCO3 **pH:** 7.2

IMMERSION IN BIOCIDE: 9/26/91
TOTAL TIME IN BIOCIDE: 69 DAYS
REMOVAL FROM BIOCIDE: 12/4/91

TEST DATE: 12/4/91
PRESSURE: 800 psi
FLOW RATE: 0.73 gpm
TEMPERATURE: 26.0 C
FEED CONDUCTIVITY: 56,000 umhos
FEED pH: 7.9

START TIME: 1050
FINISH TIME: 1150
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	8.0	1.60 x 18.3 =	29.28 x	0.962 =	28.2	1900	96.6
2	4	7.7	1.54 x 18.3 =	28.18 x	0.962 =	27.1	1400	97.5
3	6	7.4	1.48 x 18.3 =	27.08 x	0.962 =	26.1	1500	97.3
					AVG.	27.1	1600	97.1

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS **TEST #** 7
ELEMENT # 3728
MEMBRANE SHEET # 3728-2-1T
MEMBRANE I.D. # 3728-7

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/16/ 91
PRESSURE: 800 psi
FLOW RATE: 0.65 gpm
TEMPERATURE: 32.0 C
FEED CONDUCTIVITY: 61,000 umhos
FEED pH: 8.1

START TIME: 1018
FINISH TIME: 1118
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: A.V.D.L.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	3.6	0.72 x 18.3 = 13.18	x 0.765	=	10.1	540	99.1
2	3	5.7	1.14 x 18.3 = 20.86	x 0.765	=	15.9	810	98.7
3	5	7.4	1.48 x 18.3 = 27.08	x 0.765	=	20.7	750	98.8
					AVG.	15.6	700	98.9

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SUBSTITUTED ISOTHIAZOLINONE **CONC.:** 0.13% **BUFFER:** HCl/NaHCO3 **pH:** 7.1

IMMERSION IN BIOCIDE: 9/26/ 91
TOTAL TIME IN BIOCIDE: 69 DAYS
REMOVAL FROM BIOCIDE: 12/4/91

TEST DATE: 12/4/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 26.5 C
FEED CONDUCTIVITY: 56,000 umhos
FEED pH: 7.8

START TIME: 1200
FINISH TIME: 1300
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	5.1	1.02 x 18.3 = 18.67	x 0.943	=	17.6	845	98.5
2	4	5.7	1.14 x 18.3 = 20.86	x 0.943	=	19.7	900	98.4
3	6	4.8	0.96 x 18.3 = 17.57	x 0.943	=	16.6	850	98.5
					AVG.	18.0	86	98.5

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS **TEST #** 8
ELEMENT # 3728
MEMBRANE SHEET # 3728-2-2B
MEMBRANE I.D. # 3728-8

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/16/ 91
PRESSURE: 800 psi
FLOW RATE: 0.65 gpm
TEMPERATURE: 32.5 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 8.1

START TIME: 1145
FINISH TIME: 1245
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: A.V.D.L.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	6.4	1.28 x 18.3 =	23.42 x	0.780 =	18.3	880	98.5
2	3	7.3	1.46 x 18.3 =	26.72 x	0.780 =	20.8	550	99.1
3	5	7.1	1.42 x 18.3 =	26.99 x	0.780 =	21.1	960	98.4
					AVG.	20.1	797	98.7

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SUBSTITUTED ISOTHIAZOLINONE **CONC.:** 0.01% **BUFFER:** HCl/NaHCO3 **pH:** 7.4

IMMERSION IN BIOCIDE: 9/26/ 91
TOTAL TIME IN BIOCIDE: 69 DAYS
REMOVAL FROM BIOCIDE: 12/4/91

TEST DATE: 12/4/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 26.0 C
FEED CONDUCTIVITY: 56,000 umhos
FEED pH: 7.8

START TIME: 1440
FINISH TIME: 1540
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	3.8	— x 18.3 =	— x	— =	—	2100	—
2	4	5.6	1.12 x 18.3 =	20.50 x	0.962 =	19.7	880	98.4
3	6	5.2	1.04 x 18.3 =	19.03 x	0.962 =	18.3	790	98.6
					AVG.	19.0	835	98.5

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS TEST # 10
ELEMENT # 3728
MEMBRANE SHEET # 3728-3-1B
MEMBRANE I.D. # 3728-10

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/16/ 91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.7

START TIME: 1440
FINISH TIME: 1540
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 6.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	5.4	— x 18.3 = —	x 0.738 =	—	1600	—
2	3	8.1	1.35 x 18.3 = 24.71	x 0.738 =	18.2	470	99.2
3	5	9.2	1.53 x 18.3 = 28.00	x 0.738 =	20.7	520	99.1
				AVG.	19.5	495	99.1

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: BCDMH CONC.: 100 mg/L BUFFER: HCl/NaHCO3 pH: 6.5

IMMERSION IN BIOCIDE: 9/26/ 91
TOTAL TIME IN BIOCIDE: 70 DAYS
REMOVAL FROM BIOCIDE: 12/5/91

TEST DATE: 12/5/ 91
PRESSURE: 800 psi
FLOW RATE: 0.72 gpm
TEMPERATURE: 24.5 C
FEED CONDUCTIVITY: 56,000 umhos
FEED pH: 7.8

START TIME: 0810
FINISH TIME: 0910
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	6.3	1.26 x 18.3 = 23.06	x 1.02 =	23.5	1300	97.7
2	4	7.4	1.48 x 18.3 = 27.08	x 1.02 =	27.6	1500	97.3
3	6	10.8	— x 18.3 = —	x — =	—	8600	—
				AVG.	25.5	1400	97.5

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS TEST # 11
ELEMENT # 3728
MEMBRANE SHEET # 3728-3-2T
MEMBRANE I.D. # 3728-11

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/16/ 91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.7

START TIME: 1555
FINISH TIME: 1655
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 60 min.
DATA TAKEN BY:

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	8.7	1.45 x 18.3 = 26.53 x	0.738	=	19.6	530	99.1
2	3	10.4	1.73 x 18.3 = 31.66 x	0.738	=	23.4	770	98.7
3	5	10.6	1.77 x 18.3 = 32.39 x	0.738	=	23.9	750	98.7
					AVG.	22.3	683	98.8

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: BCDMH CONC.: 10 mg/L BUFFER: HCl/NaHCO3 pH: 6.4

IMMERSION IN BIOCIDE: 9/26/ 91
TOTAL TIME IN BIOCIDE: 70 DAYS
REMOVAL FROM BIOCIDE: 12/5/91

TEST DATE: 12/5/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 25.5 C
FEED CONDUCTIVITY: 56,000 umhos
FEED pH: 7.8

START TIME: 1035
FINISH TIME: 1135
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	7.7	1.54 x 18.3 = 28.18 x	0.981	=	27.6	1600	97.1
2	4	7.5	1.50 x 18.3 = 27.45 x	0.981	=	26.9	1900	96.6
3	6	7.6	1.52 x 18.3 = 27.82 x	0.981	=	27.3	1400	97.5
					AVG.	27.3	1633	97.1

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS TEST # 12
ELEMENT # 3728
MEMBRANE SHEET # 3728-3-2B
MEMBRANE I.D. # 3728-12

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/17/ 91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 32 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.5

START TIME: 0835
FINISH TIME: 0935
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 6.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	1	5.1	0.85 x 18.3 =	15.56x	0.765	=	11.9	350	99.4
2	3	8.2	1.37 x 18.3 =	25.07x	0.765	=	19.2	380	99.4
3	5	9.2	1.53 x 18.3 =	28.00x	0.765	=	21.4	550	99.1
						AVG.	17.5	427	99.3

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: BCDMH CONC.: 1 mg/L BUFFER: $HCl/NaHCO_3$ pH: 7.1

IMMERSION IN BIOCIDE: 9/26/ 91
TOTAL TIME IN BIOCIDE: 70 DAYS
REMOVAL FROM BIOCIDE: 12/5/91

TEST DATE: 12/5/ 91
PRESSURE: 800 psi
FLOW RATE: 0.78 gpm
TEMPERATURE: 26.0 C
FEED CONDUCTIVITY: 54,000 umhos
FEED pH: 7.8

START TIME: 1420
FINISH TIME: 1520
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5 min.
DATA TAKEN BY: C.E.M

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	2	4.9	0.98 x 18.3 =	17.93x	0.962	=	17.2	600	98.9
2	4	5.9	1.18 x 18.3 =	21.59x	0.962	=	20.8	630	98.9
3	6	4.8	0.96 x 18.3 =	17.57x	0.962	=	16.9	600	98.9
						AVG.	18.3	610	98.9

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS TEST # 13
ELEMENT # 3728
MEMBRANE SHEET # 3728-4-1T
MEMBRANE I.D. # 3728-13

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/17/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.5

START TIME: 1010
FINISH TIME: 1110
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 60.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	7.1	1.18 x 18.3 =	21.59 x	0.738 =	15.9	620	99.0
2	3	8.2	1.37 x 18.3 =	25.07 x	0.738 =	18.5	380	99.4
3	5	8.9	1.48 x 18.3 =	27.08 x	0.738 =	20.0	420	99.3
					AVG.	18.1	473	99.2

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: BROMONITRO-PROPANEDIOL CONC.: 0.5% BUFFER: HCl/NaHCO3 pH: 4.0

IMMERSION IN BIOCIDE: 9/27/ 91
TOTAL TIME IN BIOCIDE: 69 DAYS
REMOVAL FROM BIOCIDE: 12/5/91

TEST DATE: 12/5/ 91
PRESSURE: 800 psi
FLOW RATE: 0.78 gpm
TEMPERATURE: 26.0 C
FEED CONDUCTIVITY: 56,000 umhos
FEED pH: 7.8

START TIME: 1550
FINISH TIME: 1650
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	5.4	1.08 x 18.3 =	19.76 x	0.962 =	19.0	900	98.4
2	4	3.8	0.76 x 18.3 =	13.91 x	0.962 =	13.4	880	98.4
3	6	4.2	0.84 x 18.3 =	15.37 x	0.962 =	14.8	940	98.3
					AVG.	15.7	907	98.4

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS TEST # 15
ELEMENT # 3728
MEMBRANE SHEET # 3728-4-2T
MEMBRANE I.D. # 3728-15

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/17/ 91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.7

START TIME: 1350
FINISH TIME: 1450
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 6.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	6.6	1.10 x 18.3 =	20.13 x	0.738 =	14.9	620	99.0
2	3	8.9	1.48 x 18.3 =	27.08 x	0.738 =	20.0	485	99.2
3	5	8.6	1.43 x 18.3 =	— x	0.738 =	—	1700	—
					AVG.	17.5	553	99.1

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: BROMONITRO-PROPANEDIOL CONC.: 0.10% BUFFER: HCl/NaHCO3 pH: 6.0

IMMERSION IN BIOCIDE: 9/27/ 91
TOTAL TIME IN BIOCIDE: 70 DAYS
REMOVAL FROM BIOCIDE: 12/6/91

TEST DATE: 12/6/ 91
PRESSURE: 800 psi
FLOW RATE: 0.75 gpm
TEMPERATURE: 25.0 C
FEED CONDUCTIVITY: 56,000 umhos
FEED pH: 7.8

START TIME: 0920
FINISH TIME: 1020
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	4.2	0.84 x 18.3 =	15.37 x	1.00 =	15.37	800	98.6
2	4	4.9	0.98 x 18.3 =	17.93 x	1.00 =	17.93	800	98.6
3	6	4.7	0.94 x 18.3 =	17.20 x	1.00 =	17.20	900	98.4
					AVG.	No.8	833	98.5

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS TEST # 17
ELEMENT # 3728
MEMBRANE SHEET # 3728-5-1T
MEMBRANE I.D. # 3728-17

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/18/ 91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 32 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.3

START TIME: 0800
FINISH TIME: 0900
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY:

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
* 1	1	8.1	1.62 x 18.3 =	29.65 x	0.765 =	22.7	790	98.7
* 2	3	9.2	1.84 x 18.3 =	33.67 x	0.765 =	25.7	1000	98.3
3	5	8.9	1.78 x 18.3 =	32.57 x	0.765 =	24.9	870	98.5
					AVG.	24.4	887	98.5

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: BROMONITRO-PROPANEDIOL CONC.: 0.01% BUFFER: HCl/NaHCO3 pH: 6.3

IMMERSION IN BIOCIDE: 9/27/ 91
TOTAL TIME IN BIOCIDE: 70 DAYS
REMOVAL FROM BIOCIDE: 12/6/91

TEST DATE: 12/6/ 91
PRESSURE: 800 psi
FLOW RATE: 0.72 gpm
TEMPERATURE: 25.5 C
FEED CONDUCTIVITY: 56,000 umhos
FEED pH: 7.8

START TIME: 1255
FINISH TIME: 1355
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	6.6	1.32 x 18.3 =	24.16 x	0.981 =	23.7	1700	97.0
2	4	5.9	1.18 x 18.3 =	21.59 x	0.981 =	21.2	1200	97.9
3	6	6.9	1.38 x 18.3 =	25.25 x	0.981 =	24.8	1200	97.9
					AVG.	23.2	1367	97.6

* DENT IN POROUS SS PLATE (MAY AFFECT RESULTS)

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS TEST # 18
ELEMENT # 3728
MEMBRANE SHEET # 3728-5-18
MEMBRANE I.D. # 3728-18

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/18/ 91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 32.5 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.3

START TIME: 0940
FINISH TIME: 1040
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 6.0 min.
DATA TAKEN BY:

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	6.6	1.10 x 18.3 = 20.13 x	0.752	=	15.1	520	99.1
2	3	9.1	1.52 x 18.3 = 27.82 x	0.752	=	20.9	500	99.2
3	5	7.8	1.30 x 18.3 = 23.79 x	0.752	=	17.9	970	98.4
					AVG.	18.0	663	98.9

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: CETYLTRIMETHAMMONIUM P-TOLUENE SULFONATE CONC.: 0.5% BUFFER: pH: 7.9

IMMERSION IN BIOCIDE: 9/24/ 91
TOTAL TIME IN BIOCIDE: 76 DAYS
REMOVAL FROM BIOCIDE: 12/9/91

TEST DATE: 12/9/ 91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 25.5 C
FEED CONDUCTIVITY: 56,000 umhos
FEED pH: 8.7

START TIME: 1020
FINISH TIME: 1120
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: A.V.D.L.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2*	5.1	1.02 x 18.3 = 18.67 x	0.981	=	18.3	1200	97.8
2	4	6.0	1.20 x 18.3 = 21.96 x	0.981	=	21.5	760	98.6
3	6	6.7	1.34 x 18.3 = 24.52 x	0.981	=	24.1	880	98.4
					AVG.	21.3	947	98.3

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS TEST # 20
ELEMENT # 3728
MEMBRANE SHEET # 3728-5-2B
MEMBRANE I.D. # 3728-20

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/18/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.7

START TIME: 1230
FINISH TIME: 1330
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	6.3	1.26 x 18.3 =	23.06x	0.738 =	17.0	350	99.4
2	3	8.0	1.60 x 18.3 =	29.28x	0.738 =	21.6	480	99.2
3	5	8.0	1.60 x 18.3 =	29.28x	0.738 =	—	1500	—
					AVG.	19.3	415	99.3

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: CETYL TRIMETHAMMONIUM P-TOLUENE SULFONATE CONC.: 0.1 % BUFFER: pH: 8.5

IMMERSION IN BIOCIDE: 9/24/ 91
TOTAL TIME IN BIOCIDE: 76 DAYS
REMOVAL FROM BIOCIDE: 12/9/91

TEST DATE: 12/9/ 91
PRESSURE: 800 psi
FLOW RATE: 0.71 gpm
TEMPERATURE: 26.0 C
FEED CONDUCTIVITY: 56,000 umhos
FEED pH: 8.7

START TIME: 1330
FINISH TIME: 1430
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: A.V.D.L.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	5.0	1.00 x 18.3 =	18.30x	0.962 =	17.6	760	98.6
2	4	5.8	1.16 x 18.3 =	21.23x	0.962 =	20.4	970	98.3
3	6	7.1	— x 18.3 =	— x	— =	—	2200	—
					AVG.	19.0	865	98.5

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS **TEST #** 21
ELEMENT # 3728
MEMBRANE SHEET # 3728-6-1T
MEMBRANE I.D. # 3728-21

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/18/ 91
PRESSURE: 800 psi
FLOW RATE: 0.67 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.7

START TIME: 1415
FINISH TIME: 1515
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 6.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	6.6	1.10 x 18.3 =	20.13 x	0.738 =	14.9	610	99.0
2	3	8.6	1.43 x 18.3 =	26.17 x	0.738 =	19.3	550	99.1
3	5	8.9	1.48 x 18.3 =	27.08 x	0.738 =	20.0	700	98.8
					AVG.	18.1	620	99.0

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: ~~P-TOLUENE SULFONATE~~ CETYLTRIMETHAMMONIUM **CONC.:** 0.01% **BUFFER:** HCl/NaHCO3 **pH:** 8.0

IMMERSION IN BIOCIDE: 9/27/ 91
TOTAL TIME IN BIOCIDE: 75 DAYS
REMOVAL FROM BIOCIDE: 12/11/91

TEST DATE: 12/11/ 91
PRESSURE: 800 psi
FLOW RATE: 0.72 gpm
TEMPERATURE: 25.5 C
FEED CONDUCTIVITY: 55,000 umhos
FEED pH: 7.6

START TIME: 0935
FINISH TIME: 1035
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	6.2	1.24 x 18.3 =	22.69 x	0.981 =	22.3	960	98.3
2	4	5.4	1.08 x 18.3 =	19.76 x	0.981 =	19.4	680	98.8
3	6	6.8	1.36 x 18.3 =	24.89 x	0.981 =	24.4	1150	97.9
					AVG.	22.0	930	98.3

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS TEST # 22
ELEMENT # 3728
MEMBRANE SHEET # 3728-6-18
MEMBRANE I.D. # 3728-22

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/18/ 91
PRESSURE: 800 psi
FLOW RATE: 0.67 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.5

START TIME: 1545
FINISH TIME: 1645
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	9.4	1.88 x 18.3 = 34.40 x		0.738 =	—	1200	—
2	3	9.0	1.80 x 18.3 = 32.94 x		0.738 =	24.3	800	98.7
3	5	9.7	1.94 x 18.3 = 35.50 x		0.738 =	26.2	820	98.6
					AVG.	25.3	810	98.7

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SODIUM BENZOATE CONC.: 0.5% BUFFER: HCl/NaHCO3 pH:

IMMERSION IN BIOCIDE: 9/27/ 91
TOTAL TIME IN BIOCIDE: 75 DAYS

REMOVAL FROM BIOCIDE: 12/11/91

TEST DATE: 12/11/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 26.0 C
FEED CONDUCTIVITY: 55,000 umhos
FEED pH: 7.7

START TIME: 1230
FINISH TIME: 1330
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	8.2	1.64 x 18.3 = 30.01 x		0.962 =	28.9	1250	97.7
2	4	7.9	1.58 x 18.3 = 28.91 x		0.962 =	27.8	1050	98.1
3	6	8.1	1.62 x 18.3 = 29.65 x		0.962 =	28.5	980	98.2
					AVG.	28.4	1093	98.0

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS TEST # 24
ELEMENT # 3728
MEMBRANE SHEET # 3728-6-2B
MEMBRANE I.D. # 3728-24

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/19/ 91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 32 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.5

START TIME: 0945
FINISH TIME: 1045
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	8.2	1.64 x 18.3 =	30.01 x	0.765 =	22.9	900	98.5
2	3	8.5	— x 18.3 =	— x	— =	—	1200	—
3	5	9.2	1.84 x 18.3 =	33.67 x	0.765 =	25.7	860	98.6
					AVG.	24.3	880	98.5

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SODIUM BENZOATE CONC.: 0.1% BUFFER: HCl/NaHCO3 pH: 6.35

IMMERSION IN BIOCIDE: 9/25/ 91
TOTAL TIME IN BIOCIDE: 75 DAYS
REMOVAL FROM BIOCIDE: 12/13/91

TEST DATE: 12/13/ 91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 24.0 C
FEED CONDUCTIVITY: 55,000 umhos
FEED pH: 8.3

START TIME: 0805
FINISH TIME: 0905
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: A.V.D.L.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	7.4	1.48 x 18.3 =	27.08 x	1.04 =	28.2	1400	97.5
2	4	7.2	1.44 x 18.3 =	26.35 x	1.04 =	27.4	960	98.3
3	6	7.2	1.44 x 18.3 =	26.35 x	1.04 =	27.4	1400	97.5
					AVG.	27.7	1253	97.8

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS TEST # 26
ELEMENT # 3728
MEMBRANE SHEET # 3728-7-1B
MEMBRANE I.D. # 3728-26

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/19/91
PRESSURE: 800 psi
FLOW RATE: 0.66 gpm
TEMPERATURE: 32.5 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.5

START TIME: 1220
FINISH TIME: 1320
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY:

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	6.2	1.24 x 18.3 =	22.69 x	0.752 =	17.1	825	98.6
2	3	7.9	1.58 x 18.3 =	28.91 x	0.752 =	21.7	650	98.9
3	5	7.1	— x 18.3 =	— x	— =	—	3600	—
					AVG.	19.4	737	98.7

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SODIUM BENZOATE CONC.: 0.01% BUFFER: HCl/NaHCO3 pH: 5.95

IMMERSION IN BIOCIDE: 9/25/91
TOTAL TIME IN BIOCIDE: 75 DAYS
REMOVAL FROM BIOCIDE: 12/13/91

TEST DATE: 12/13/91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 25.5 C
FEED CONDUCTIVITY: 55,000 umhos
FEED pH: 8.3

START TIME: 1035
FINISH TIME: 1135
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: A.V.D.L.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	6.4	1.28 x 18.3 =	23.42 x	0.981 =	23.0	950	98.3
2	4	5.3	1.06 x 18.3 =	19.40 x	0.981 =	19.0	810	98.5
3	6	5.2	1.04 x 18.3 =	19.03 x	0.981 =	18.7	730	98.7
					AVG.	20.2	830	98.5

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS TEST # 29
ELEMENT # 3728
MEMBRANE SHEET # 3728-8-1T
MEMBRANE I.D. # 3728-29

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/20/ 91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 32 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.5

START TIME: 0830
FINISH TIME: 0935
ELAPSED TIME: 1.1 hr.
COLLECTION TIME: 5.0 min.

DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	1	7.3	1.46 x 18.3 =	26.72 x	0.765	=	20.4	810	98.7
2	3	8.3	1.66 x 18.3 =	30.38 x	0.765	=	23.2	970	98.4
3	5	8.3	1.66 x 18.3 =	30.38 x	0.765	=	23.2	880	98.5
					AVG.		22.3	887	98.5

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: EDTA CONC.: 0.5% BUFFER: HCl/NaHCO3 pH: 5.15

IMMERSION IN BIOCIDE: 9/25/ 91
TOTAL TIME IN BIOCIDE: 75 DAYS

REMOVAL FROM BIOCIDE: 12/13/91

TEST DATE: 12/13/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 27.0 C
FEED CONDUCTIVITY: 55,000 umhos
FEED pH: 8.3

START TIME: 1415
FINISH TIME: 1515
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.

DATA TAKEN BY:

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	2	7.3	1.46 x 18.3 =	26.72 x	0.925	=	24.7	1600	97.1
2	4	8.1	1.62 x 18.3 =	29.65 x	0.925	=	27.4	1400	97.5
3	6	8.0	1.60 x 18.3 =	29.28 x	0.925	=	27.1	1400	97.5
					AVG.		26.4	1467	97.4

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS **TEST #** 30
ELEMENT # 3728
MEMBRANE SHEET # 3728-8-1B
MEMBRANE I.D. # 3728-30

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/20/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 32 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.5

START TIME: 0950
FINISH TIME: 1050
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	6.7	1.34 x 18.3 =	24.52 x	0.765 =	18.7	775	98.7
2	3	8.0	1.60 x 18.3 =	29.28 x	0.765 =	22.4	680	98.9
3	5	7.8	1.56 x 18.3 =	28.55 x	0.765 =	21.8	980	98.4
					AVG.	21.0	812	98.7

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: EDTA **CONC.:** 0.1% **BUFFER:** HCl/$NaHCO_3$ **pH:** 5.4

IMMERSION IN BIOCIDE: 9/25/ 91
TOTAL TIME IN BIOCIDE: 78 DAYS
REMOVAL FROM BIOCIDE: 12/16/91

TEST DATE: 12/16/ 91
PRESSURE: 800 psi
FLOW RATE: 0.71 gpm
TEMPERATURE: 24.0 C
FEED CONDUCTIVITY: 55,000 umhos
FEED pH: 7.85

START TIME: 0845
FINISH TIME: 0945
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 6.0 min.
DATA TAKEN BY: A.V.D.L

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	6.9	1.15 x 18.3 =	21.05 x	1.04 =	21.9	900	98.4
2	4	7.6	1.27 x 18.3 =	23.24 x	1.04 =	24.2	980	98.2
3	6	7.0	1.17 x 18.3 =	21.41 x	1.04 =	22.3	940	98.3
					AVG.	22.8	940	98.3

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS TEST # 14
ELEMENT # 3728
MEMBRANE SHEET # 3728-4-1B
MEMBRANE I.D. # 3728-14

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/17/ 91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.7

START TIME: 1210
FINISH TIME: 1310
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	8.5	1.70 x 18.3 = 31.11 x	0.738	=	22.9	600	99.0
2	3	8.9	1.78 x 18.3 = 32.57 x	0.738	=	24.0	750	98.7
3	5	9.1	1.82 x 18.3 = — x	0.738	=	—	1500	—
					AVG.	23.8	675	98.9

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: EDTA CONC.: 0.01% BUFFER: HCl/NaHCO3 pH: 4.95

IMMERSION IN BIOCIDE: 9/25 91
TOTAL TIME IN BIOCIDE: 78 DAYS
REMOVAL FROM BIOCIDE: 12/16/91

TEST DATE: 12/16/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 25.0 C
FEED CONDUCTIVITY: 55,000 umhos
FEED pH: 7.85

START TIME: 1145
FINISH TIME: 1245
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 6.0 min.
DATA TAKEN BY: A.V.D.L.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	8.5	1.42 x 18.3 = 25.99 x	1.00	=	26.0	1400	97.5
2	4	8.2	1.37 x 18.3 = 25.07 x	1.00	=	25.1	1200	97.8
3	6	8.5	1.42 x 18.3 = 25.99 x	1.00	=	26.0	1300	97.6
					AVG.	25.7	1300	97.6

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS TEST # 31
ELEMENT # 3728 (SAME ELEMENT, NEW CUT)
MEMBRANE SHEET # 3728-9
MEMBRANE I.D. # 3728-31

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/1/91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 32.5 C
FEED CONDUCTIVITY: 61,000 umhos
FEED pH: 7.5

START TIME: 0945
FINISH TIME: 1045
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY:

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	7.7	1.54 x 18.3 =	28.18 x	0.752 =	21.2	620	99.0
2	3	7.4	1.48 x 18.3 =	27.08 x	0.752 =	20.4	480	99.2
3	5	8.4	1.68 x 18.3 =	30.74 x	0.752 =	23.1	610	99.0
					AVG.	21.6	570	99.1

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SODIUM BENZOATE EDTA (50:50) CONC.: 0.5% BUFFER: HCl/NaHCO3 pH:

IMMERSION IN BIOCIDE: 10/3/91
TOTAL TIME IN BIOCIDE: 74 DAYS
REMOVAL FROM BIOCIDE: 12/16/91

TEST DATE: 12/16/91
PRESSURE: 800 psi
FLOW RATE: 0.80 gpm
TEMPERATURE: 25.0 C
FEED CONDUCTIVITY: 55,000 umhos
FEED pH: 7.85

START TIME: 1500
FINISH TIME: 1615
ELAPSED TIME: 1.25 hr.
COLLECTION TIME: 6.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	7.4	1.23 x 18.3 =	22.51 x	1.00 =	22.5	650	98.8
2	4	8.4	1.40 x 18.3 =	25.62 x	1.00 =	25.6	940	98.3
3	6	8.0	1.33 x 18.3 =	24.34 x	1.00 =	24.3	740	98.7
					AVG.	24.1	777	98.6

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS TEST # 32
ELEMENT # 3728 (SAME ELEMENT, NEW CUT)
MEMBRANE SHEET # 3728-10
MEMBRANE I.D. # 3728-32

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/1/91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.5

START TIME: 1115
FINISH TIME: 1215
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	1	7.6	1.52 x 18.3 =	27.82 x	0.738	=	20.5	740	98.8
2	3	6.8	1.36 x 18.3 =	24.89 x	0.738	=	18.4	530	99.1
3	5	8.2	1.64 x 18.3 =	30.01 x	0.738	=	22.1	850	98.6
					AVG.		20.3	707	98.8

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SODIUM BENZOATE EDTA (50:50) CONC.: 0.05% BUFFER: $HCl/NaHCO_3$ pH: 5.0

IMMERSION IN BIOCIDE: 10/3/91
TOTAL TIME IN BIOCIDE: 75 DAYS

REMOVAL FROM BIOCIDE: 12/17/91

TEST DATE: 12/17/91
PRESSURE: 800 psi
FLOW RATE: 0.71 gpm
TEMPERATURE: 25.0 C
FEED CONDUCTIVITY: 55,000 umhos
FEED pH: 7.45

START TIME: 1050
FINISH TIME: 1150
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 7.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	2	8.5	1.21 x 18.3 =	22.14 x	1.00	=	22.1	840	98.5
2	4	9.2	1.31 x 18.3 =	23.97 x	1.00	=	24.0	900	98.4
3	6	10.0	1.43 x 18.3 =	26.17 x	1.00	=	26.2	1100	98.0
					AVG.		24.1	947	98.3

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS — TEST # 33
ELEMENT # 3728 (SAME ELEMENT, NEW CUT)
MEMBRANE SHEET # 3728-11
MEMBRANE I.D. # 3728-33

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/1/91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.5

START TIME: 1240
FINISH TIME: 1340
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	6.1	1.22 x 18.3 =	22.33x	0.738 =	16.5	460	99.2
2	3	5.2	1.04 x 18.3 =	19.03x	0.738 =	14.0	360	99.4
3	5	6.4	1.28 x 18.3 =	23.42x	0.738 =	17.3	460	99.2
					AVG.	15.9	427	99.3

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SODIUM BENZOATE EDTA (50:50) CONC.: 0.01 BUFFER: $HCl/NaHCO_3$ pH:

IMMERSION IN BIOCIDE: 10/3/91
TOTAL TIME IN BIOCIDE: 75 DAYS
REMOVAL FROM BIOCIDE: 12/17/91

TEST DATE: 12/17/91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 25.0 C
FEED CONDUCTIVITY: 55,000 umhos
FEED pH: 7.45

START TIME: 1605
FINISH TIME: 1705
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 7.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	6.1	0.87 x 18.3 =	15.92x	1.00 =	15.9	1100	98.0
2	4	6.5	0.93 x 18.3 =	17.02x	1.00 =	17.0	630	98.9
3	6	7.2	1.03 x 18.3 =	18.85x	1.00 =	18.9	1060	98.8
					AVG.	17.3	797	98.6

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS TEST # 34
ELEMENT # 3728 (SAME ELEMENT, NEW CUT)
MEMBRANE SHEET # 3728-12
MEMBRANE I.D. # 3728-34

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/1/91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.5

START TIME: 1430
FINISH TIME: 1530
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN		AREA CORR.		TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	1	8.0	1.60	x 18.3 =	29.28	x	0.738	=	21.6	700	98.8
2	3	8.1	1.62	x 18.3 =	29.65	x	0.738	=	21.9	830	98.6
3	5	7.4	1.48	x 18.3 =	27.08	x	0.738	=	20.0	790	98.7
								AVG.	21.2	773	98.7

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: GLUTERALDEHYDE CONC.: 3.0% BUFFER: $HCl/NaHCO_3$ pH: 5.10

IMMERSION IN BIOCIDE: 10/4/91
TOTAL TIME IN BIOCIDE: 75 DAYS
REMOVAL FROM BIOCIDE: 12/18/91

TEST DATE: 12/18/91
PRESSURE: 800 psi
FLOW RATE: 0.72 gpm
TEMPERATURE: 24.0 C
FEED CONDUCTIVITY: 55,000 umhos
FEED pH: 7.7

START TIME: 0835
FINISH TIME: 0935
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN		AREA CORR.		TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	2	5.0	1.00	x 18.3 =	18.30	x	1.04	=	19.0	940	98.3
2	4	5.5	1.10	x 18.3 =	20.13	x	1.04	=	20.9	1050	98.1
3	6	4.2	0.84	x 18.3 =	15.37	x	1.04	=	16.0	840	98.5
								AVG.	18.6	943	98.3

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS TEST # 35
ELEMENT # 3728 (SAME ELEMENT, NEW CUT)
MEMBRANE SHEET # 3728-13
MEMBRANE I.D. # 3728-35

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/1/91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 32.5 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.3

START TIME: 1545
FINISH TIME: 1645
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 6.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	6.1	1.02 x 18.3 = 18.61	x 0.752	=	14.0	640	98.9
2	3	7.1	1.18 x 18.3 = 21.59	x 0.752	=	16.2	360	99.4
3	5	6.8	1.13 x 18.3 = 20.68	x 0.752	=	15.5	410	99.3
					AVG.	15.2	470	99.2

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: GLUTERALDEHYDE CONC.: 1.0% BUFFER: $HCl/NaHCO_3$ pH: 5.6

IMMERSION IN BIOCIDE: 10/4/91
TOTAL TIME IN BIOCIDE: 75 DAYS
REMOVAL FROM BIOCIDE: 12/18/91

TEST DATE: 12/18/91
PRESSURE: 800 psi
FLOW RATE: 0.63 gpm
TEMPERATURE: 25.0 C
FEED CONDUCTIVITY: 55,000 umhos
FEED pH: 7.7

START TIME: 1130
FINISH TIME: 1230
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 6.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	5.9	0.98 x 18.3 = 17.93	x 1.00	=	17.9	520	99.1
2	4	5.0	0.83 x 18.3 = 15.19	x 1.00	=	15.2	640	98.8
3	6	4.3	0.72 x 18.3 = 13.18	x 1.00	=	13.2	740	98.7
					AVG.	15.4	633	98.9

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS TEST # 36
ELEMENT # 3728 (SAME ELEMENT, NEW CUT)
MEMBRANE SHEET # 3728-14
MEMBRANE I.D. # 3728-36

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/2/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 32 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: _____

START TIME: 0845
FINISH TIME: 0945
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	7.4	1.48 x 18.3 =	27.08 x	0.765 =	20.7	640	98.9
*2	3	—	— x 18.3 =	— x	— =	—	—	—
3	5	8.4	1.68 x 18.3 =	30.74 x	0.765 =	23.5	770	98.7
					AVG.	22.1	705	98.8

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: GLUTERALDEHYDE CONC.: 0.5% BUFFER: $HCl/NaHCO_3$ pH: _____

IMMERSION IN BIOCIDE: 10/4/ 91
TOTAL TIME IN BIOCIDE: 75 DAYS
REMOVAL FROM BIOCIDE: 12/18/91

TEST DATE: 12/18/ 91
PRESSURE: 800 psi
FLOW RATE: 0.72 gpm
TEMPERATURE: 25.5 C
FEED CONDUCTIVITY: 55,000 umhos
FEED pH: 7.7

START TIME: 1420
FINISH TIME: 1520
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	5.9	1.18 x 18.3 =	21.59 x	0.981 =	21.2	820	98.5
2	4	6.3	1.26 x 18.3 =	23.06 x	0.981 =	22.6	1000	98.2
3	6	6.3	1.26 x 18.3 =	23.06 x	0.981 =	22.6	1200	97.8
					AVG.	22.1	1007	98.2

*NO FLOW. PLASTIC ON MEMBRANE SURFACE.

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS TEST # 37
ELEMENT # 3728 (SAME ELEMENT, NEW CUT)
MEMBRANE SHEET # 3728-15
MEMBRANE I.D. # 37

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/2/91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 32.5 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.4

START TIME: 1015
FINISH TIME: 1115
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	1	6.1	1.22 x 18.3 =	22.33 x	0.752	=	16.8	440	99.3
2	3	5.6	1.12 x 18.3 =	20.50 x	0.752	=	15.4	380	99.4
3	5	6.2	1.24 x 18.3 =	22.69 x	0.752	=	17.1	400	99.3
					AVG.		16.4	407	99.3

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SODIUM BISULFITE/GLYCERINE CONC.: 1.0%/20.0% BUFFER: $HC_4/NaHCO_3$ pH: 7.1

IMMERSION IN BIOCIDE: 10/4/91
TOTAL TIME IN BIOCIDE: 76 DAYS
REMOVAL FROM BIOCIDE: 12/19/91

TEST DATE: 12/19/91
PRESSURE: 800 psi
FLOW RATE: 0.72 gpm
TEMPERATURE: 24.5 C
FEED CONDUCTIVITY: 55,000 umhos
FEED pH: 7.6

START TIME: 1055
FINISH TIME: 1155
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	2	4.5	0.90 x 18.3 =	16.47 x	1.02	=	16.8	670	98.8
2	4	5.0	1.00 x 18.3 =	18.30 x	1.02	=	18.7	710	98.7
3	6	4.5	0.90 x 18.3 =	16.47 x	1.02	=	16.8	790	98.6
					AVG.		17.4	723	98.7

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS TEST # 38
ELEMENT # 3728 (SAME ELEMENT, NEW CUT)
MEMBRANE SHEET # 3728-16
MEMBRANE I.D. # 3728-38

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/2/91
PRESSURE: 800 psi
FLOW RATE: 0.67 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.4

START TIME: 1140
FINISH TIME: 1240
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: A.V.D.L.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	1	6.3	1.26 x 18.3 =	23.06 x	0.738	=	17.0	530	99.1
2	3	5.2	1.04 x 18.3 =	19.03 x	0.738	=	14.0	430	99.3
3	5	6.1	1.22 x 18.3 =	22.33 x	0.738	=	16.5	520	99.1
					AVG.		15.8	493	99.2

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: CONTROL CONC.: DI WATER BUFFER: $HCl/NaHCO_3$ pH: 5.5

IMMERSION IN BIOCIDE: 10/11/91
TOTAL TIME IN BIOCIDE: 70 DAYS
REMOVAL FROM BIOCIDE: 12/20/91

TEST DATE: 12/20/91
PRESSURE: 800 psi
FLOW RATE: 0.78 gpm
TEMPERATURE: 25.0 C
FEED CONDUCTIVITY: 55,000 umhos
FEED pH: 7.7

START TIME: 1300
FINISH TIME: 1400
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	2	4.2	0.84 x 18.3 =	15.37 x	1.00	=	15.4	520	99.1
2	4	4.7	0.94 x 18.3 =	17.20 x	1.00	=	17.2	570	99.0
3	6	4.9	0.98 x 18.3 =	17.93 x	1.00	=	17.9	690	98.7
					AVG.		16.8	593	98.9

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS TEST # 40
ELEMENT # 3728 (SAME ELEMENT, NEW CUT)
MEMBRANE SHEET # 3728-18
MEMBRANE I.D. # 3728-40

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/2/91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.5

START TIME: 1520
FINISH TIME: 1620
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	5.6	1.12 x 18.3 =	20.50 x	0.738 =	15.1	530	99.1
2	3	5.7	1.14 x 18.3 =	20.86 x	0.738 =	15.4	430	99.3
3	5	6.0	1.20 x 18.3 =	21.96 x	0.738 =	16.2	530	99.1
					AVG.	15.6	497	99.2

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: CONTROL CONC.: BUFFER: $HCl/NaHCO_3$ pH: 6.3

IMMERSION IN BIOCIDE: 1/7/91
TOTAL TIME IN BIOCIDE: 88 DAYS
REMOVAL FROM BIOCIDE: 1/7/92

TEST DATE: 1/7/92
PRESSURE: 800 psi
FLOW RATE: 0.73 gpm
TEMPERATURE: 24.0 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 7.7

START TIME: 1045
FINISH TIME: 1145
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 7.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	7.6	1.09 x 18.3 =	19.95 x	1.04 =	20.7	900	98.4
2	4	7.3	1.04 x 18.3 =	19.03 x	1.04 =	19.8	700	98.8
3	6	5.3	0.76 x 18.3 =	13.91 x	1.04 =	14.5	680	98.8
					AVG.	18.3	760	98.7

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS TEST # 43
ELEMENT # 3728 (SAME ELEMENT, NEW CUT)
MEMBRANE SHEET # 3728-21
MEMBRANE I.D. # 3728-43

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/3/91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.6

START TIME: 1100
FINISH TIME: 1200
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	1	6.3	1.26 x 18.3 =	23.06x	0.738	=	17.0	610	99.0
2	3	5.9	1.18 x 18.3 =	21.59x	0.738	=	15.9	360	99.4
3	5	7.4	1.48 x 18.3 =	27.08x	0.738	=	20.0	470	99.2
					AVG.		17.6	480	99.2

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: CONTROL CONC.: BUFFER: $HCl/NaHCO_3$ pH: 7.0

IMMERSION IN BIOCIDE: 10/11/91
TOTAL TIME IN BIOCIDE: 90 DAYS
REMOVAL FROM BIOCIDE: 1/16/92

TEST DATE: 1/16/92
PRESSURE: 800 psi
FLOW RATE: 0.80 gpm
TEMPERATURE: 24.5 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 7.7

START TIME: 1218
FINISH TIME: 1318
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	2	4.3	0.86 x 18.3 =	15.74x	1.02	=	16.1	670	98.8
2	4	5.0	1.00 x 18.3 =	18.30x	1.02	=	18.7	550	99.1
3	6	4.6	0.92 x 18.3 =	16.84x	1.02	=	17.2	740	98.7
					AVG.		17.3	653	98.9

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS TEST # 48
ELEMENT # 3728 (SAME ELEMENT, NEW CUT)
MEMBRANE SHEET # 3728-216
MEMBRANE I.D. # 3728-48

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/4/91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 31 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.7

START TIME: 0940
FINISH TIME: * 1040-1112
ELAPSED TIME: 1.5 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	1	7.4	1.48 x 18.3 =	27.08 x	0.795	=	21.5	700	98.8
2	3	7.9	1.58 x 18.3 =	28.91 x	0.795	=	23.0	660	98.9
3	5	7.5	1.50 x 18.3 =	27.45 x	0.795	=	21.8	740	98.8
					AVG.		22.1	700	98.8

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SALICYLIC ACID CONC.: 0.2% BUFFER: $HCl/NaHCO_3$ pH: 6.0

IMMERSION IN BIOCIDE: 10/11/91
TOTAL TIME IN BIOCIDE: 89 DAYS
REMOVAL FROM BIOCIDE: 1/8/92

TEST DATE: 1/8/92
PRESSURE: 800 psi
FLOW RATE: 0.73 gpm
TEMPERATURE: 26.0 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.6

START TIME: 0858
FINISH TIME: 0968
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY:

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	2	7.0	1.40 x 18.3 =	25.62 x	0.962	=	24.6	1130	98.1
2	4	7.2	1.44 x 18.3 =	26.35 x	0.962	=	25.3	1130	98.1
3	6	6.8	1.36 x 18.3 =	24.89 x	0.962	=	23.9	1000	98.3
					AVG.		24.6	1087	98.2

* OVERHEATED. COOLED AT 400 PSI WITH FAN AND EVAPORATION.

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS TEST # 49
ELEMENT # 3728
MEMBRANE SHEET # 3728-27
MEMBRANE I.D. # 3728-49

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/4/91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 32.5 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.6

START TIME: 1210
FINISH TIME: 1310
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	5.9	1.18 x 18.3 =	21.59 x	0.752 =	16.2	680	98.9
2	3	6.4	1.28 x 18.3 =	23.42 x	0.752 =	17.6	520	99.1
3	5	6.4	1.28 x 18.3 =	23.42 x	0.752 =	17.6	540	99.1
					AVG.	17.1	580	99.0

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SALICYLIC ACID CONC.: 0.1% BUFFER: $HCl/NaHCO_3$ pH: 5.8

IMMERSION IN BIOCIDE: 10/11/91
TOTAL TIME IN BIOCIDE: 91 DAYS
REMOVAL FROM BIOCIDE: 1/10/912

TEST DATE: 1/10/912
PRESSURE: 800 psi
FLOW RATE: 0.66 gpm
TEMPERATURE: 26.5 C
FEED CONDUCTIVITY: 57,000 umhos
FEED pH: 7.6

START TIME: 1155
FINISH TIME: 1255
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	5.5	1.10 x 18.3 =	20.13 x	0.981 =	19.7	640	98.9
2	4	5.5	1.10 x 18.3 =	20.13 x	0.981 =	19.7	560	99.0
3	6	4.8	0.96 x 18.3 =	17.57 x	0.981 =	17.2	560	99.0
					AVG.	18.9	587	99.0

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS TEST # 50
ELEMENT # 3728
MEMBRANE SHEET # 3728-28
MEMBRANE I.D. # 3728-50

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/4/91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 32 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: _____

START TIME: 1350
FINISH TIME: 1450
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	6.1	1.22 x 18.3 =	22.33 x	0.7665 =	17.1	580	99.0
2	3	5.9	1.18 x 18.3 =	21.59 x	0.7665 =	16.5	440	99.3
3	5	6.4	1.28 x 18.3 =	23.42 x	0.7665 =	17.9	480	99.2
					AVG.	17.2	500	99.2

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SALICYLIC ACID CONC.: 0.01 % BUFFER: $HCl/NaHCO_3$ pH: 5.7

IMMERSION IN BIOCIDE: 10/11/91
TOTAL TIME IN BIOCIDE: 91 DAYS
REMOVAL FROM BIOCIDE: 1/10/92

TEST DATE: 1/10/92
PRESSURE: 800 psi
FLOW RATE: 0.73 gpm
TEMPERATURE: 25.0 C
FEED CONDUCTIVITY: 57,000 umhos
FEED pH: 7.6

START TIME: 1425
FINISH TIME: 1525
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2*	4.7	0.94 x 18.3 =	— x	1.00 =	—	3300	—
2	4	5.1	1.02 x 18.3 =	18.67 x	1.00 =	18.7	660	98.8
3	6	5.2	1.04 x 18.3 =	19.03 x	1.00 =	19.0	600	98.9
					AVG.	18.9	630	98.9

* PINHOLE FOUND IN MEMBRANE.

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS TEST # 55
ELEMENT # 3728
MEMBRANE SHEET # 3728-33
MEMBRANE I.D. # 3728-55

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/8/91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 29 C
FEED CONDUCTIVITY: 61,000 umhos
FEED pH: 7.4

START TIME: 0830
FINISH TIME: 0930
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	5.7	1.14 x 18.3 =	20.86 x	0.857 =	17.9	500	99.2
2	3	6.4	1.28 x 18.3 =	23.42 x	0.857 =	20.1	520	99.1
3	5	6.6	1.32 x 18.3 =	24.16 x	0.857 =	20.7	600	99.0
					AVG.	19.6	540	99.1

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: BENZALKONIUM CHLORIDE/EDTA (50:50) CONC.: 0.5% BUFFER: HCl/NaHCO3 pH: 5.8

IMMERSION IN BIOCIDE: 10/11/91
TOTAL TIME IN BIOCIDE: 94 DAYS
REMOVAL FROM BIOCIDE: 1/13/92

TEST DATE: 1/13/92
PRESSURE: 800 psi
FLOW RATE: 0.63 gpm
TEMPERATURE: 24.5 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 7.7

START TIME: 0840
FINISH TIME: 0940
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	5.2	1.04 x 18.3 =	19.03 x	1.02 =	19.4	730	98.7
2	4	5.2	1.04 x 18.3 =	19.03 x	1.02 =	19.4	610	98.9
3	6	4.1	0.82 x 18.3 =	15.01 x	1.02 =	15.3	1050	98.2
					AVG.	18.0	797	98.6

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS TEST # 56
ELEMENT # 3728
MEMBRANE SHEET # 3728-34
MEMBRANE I.D. # 3728-56

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/8/91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 30 C
FEED CONDUCTIVITY: 61,000 umhos
FEED pH: 7.4

START TIME: 0950
FINISH TIME: 1050
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	7.5	1.50 x 18.3 =	27.45 x	0.825 =	22.6	820	98.7
2	3	7.0	1.40 x 18.3 =	25.62 x	0.825 =	21.1	650	98.9
3	5	8.1	1.62 x 18.3 =	29.65 x	0.825 =	24.5	780	98.7
					AVG.	22.7	750	98.8

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: BENZALKONIUM CHLORIDE/EDTA (50:50) CONC.: 0.1% BUFFER: HCl/NaHCO3 pH: 5.6

IMMERSION IN BIOCIDE: 10/11/91
TOTAL TIME IN BIOCIDE: 94 DAYS
REMOVAL FROM BIOCIDE: 1/13/92

TEST DATE: 1/13/92
PRESSURE: 800 psi
FLOW RATE: 0.65 gpm
TEMPERATURE: 25.5 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 7.7

START TIME: 1124
FINISH TIME: 1224
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	5.7	1.14 x 18.3 =	20.86 x	0.981 =	20.5	760	98.7
2	4	6.6	1.32 x 18.3 =	24.16 x	0.981 =	23.7	880	98.5
3	6	6.4	1.28 x 18.3 =	23.42 x	0.981 =	23.0	910	98.4
					AVG.	22.4	850	98.5

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS TEST # 57
ELEMENT # 3728
MEMBRANE SHEET # 3728-35
MEMBRANE I.D. # 3728-57

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/8/91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 31 C
FEED CONDUCTIVITY: 61,000 umhos
FEED pH: 7.4

START TIME: 1115
FINISH TIME: 1215
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	1	6.9	1.38 x 18.3 =	25.25x	0.795	=	20.1	860	98.6
2	3	7.4	1.48 x 18.3 =	27.08x	0.795	=	21.5	850	98.6
3	5	8.0	1.60 x 18.3 =	29.28x	0.795	=	23.3	660	98.9
						AVG.	21.6	790	98.7

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: BENZALKONIUM CHLORIDE/EDTA (50:50) CONC.: 0.01% BUFFER: $HCl/NaHCO_3$ pH: 6.5

IMMERSION IN BIOCIDE: 10/11/91
TOTAL TIME IN BIOCIDE: 94 DAYS

REMOVAL FROM BIOCIDE: 1/13/92

TEST DATE: 1/13/92
PRESSURE: 800 psi
FLOW RATE: 0.78 gpm
TEMPERATURE: 25.0 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 7.7

START TIME: 1347
FINISH TIME: 1507
ELAPSED TIME: 1.3 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	2	6.7	1.34 x 18.3 =	24.52x	1.00	=	24.5	710	98.8
2	4	6.7	1.34 x 18.3 =	24.52x	1.00	=	24.5	730	98.7
3	6	5.2	1.04 x 18.3 =	19.03x	1.00	=	19.0	650	98.9
						AVG.	22.7	697	98.8

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS **TEST #** 61
ELEMENT # SE 3730 (NEW ELEMENT)*
MEMBRANE SHEET # 3730-1
MEMBRANE I.D. # 3730-61

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/18/91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 30 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.6

START TIME: 0915
FINISH TIME: 1015
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	5.0	1.00 x 18.3 = 18.30	x 0.825 =		15.1	970	98.4
2	3	5.3	1.06 x 18.3 = 19.40	x 0.825 =		16.0	560	99.1
3	5	6.5	1.30 x 18.3 = 23.79	x 0.825 =		19.6	610	99.0
					AVG.	16.9	713	98.8

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SORBIC ACID **CONC.:** 0.1% **BUFFER:** HCl/NaHCO3 **pH:** 5.5

IMMERSION IN BIOCIDE: 10/18/91
TOTAL TIME IN BIOCIDE: 88 DAYS
REMOVAL FROM BIOCIDE: 1/14/92

TEST DATE: 1/14/92
PRESSURE: 800 psi
FLOW RATE: 0.77 gpm
TEMPERATURE: 22.5 C
FEED CONDUCTIVITY: 57,000 umhos
FEED pH: 7.7

START TIME: 0810
FINISH TIME: 0910
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	4.7	0.94 x 18.3 = 17.20	x 1.104 =		19.0	490	99.1
2	4	5.1	1.02 x 18.3 = 18.67	x 1.104 =		20.6	640	98.9
3	6	5.6	1.12 x 18.3 = 20.50	x 1.104 =		22.6	630	99.0
					AVG.	20.7	587	99.0

*SAMPLES STORED IN 40% GLYCEROL AND GLUTEALDEHYDE.

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS **TEST #** 62
ELEMENT # SE 3730 (NEW ELEMENT)*
MEMBRANE SHEET # 3730-2
MEMBRANE I.D. # 3730-62

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/18/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 31 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.0

START TIME: 1045
FINISH TIME: 1145
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	8.1	1.62 x 18.3 =	29.65 x	0.795 =	23.6	960	98.4
2	3	7.0	1.40 x 18.3 =	25.62 x	0.795 =	20.4	800	98.7
3	5	7.1	1.42 x 18.3 =	25.99 x	0.795 =	20.7	860	98.6
					AVG.	21.6	873	98.6

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SORBIC ACID **CONC.:** 0.05 % **BUFFER:** $HCl/NaHCO_3$ **pH:** 5.5

IMMERSION IN BIOCIDE: 10/18/ 91
TOTAL TIME IN BIOCIDE: 88 DAYS
REMOVAL FROM BIOCIDE: 1/14/92

TEST DATE: 1/14/ 92
PRESSURE: 800 psi
FLOW RATE: 0.75 gpm
TEMPERATURE: 24.5 C
FEED CONDUCTIVITY: 57,000 umhos
FEED pH: 7.7

START TIME: 1035
FINISH TIME: 1135
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	7.0	1.40 x 18.3 =	25.62 x	1.02 =	26.1	1050	98.1
2	4	7.0	1.40 x 18.3 =	25.62 x	1.02 =	26.1	1000	98.2
3	6	6.5	1.30 x 18.3 =	23.79 x	1.02 =	24.3	950	98.3
					AVG.	25.5	1000	98.2

*SAMPLES STORED IN 40% GLYCEROL AND GLUTEALDEHYDE.

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FLUID SYSTEMS **TEST #** 63
ELEMENT # SE 3730
MEMBRANE SHEET # 3730-3
MEMBRANE I.D. # 3730-63

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/18/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 32 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.6

START TIME: 1245
FINISH TIME: 1405
ELAPSED TIME: 1.3 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	4.8	0.96 x 18.3 =	17.57 x	0.765 =	13.4	300	99.5
2	3	5.4	1.08 x 18.3 =	19.76 x	0.765 =	15.1	380	99.4
3	5	6.0	1.20 x 18.3 =	21.96 x	0.765 =	16.8	540	99.1
					AVG.	15.1	407	99.3

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SORBIC ACID **CONC.:** 0.01 % **BUFFER:** HCl/NaHCO3 **pH:** 5.5

IMMERSION IN BIOCIDE: 10/18/ 91
TOTAL TIME IN BIOCIDE: 88 DAYS
REMOVAL FROM BIOCIDE: 1/14/92

TEST DATE: 1/14/ 92
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 25.5 C
FEED CONDUCTIVITY: 57,000 umhos
FEED pH: 7.7

START TIME: 1305
FINISH TIME: 1405
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	6.5	1.30 x 18.3 =	23.79 x	0.981 =	23.3	720	98.7
2	4	5.1	1.02 x 18.3 =	18.67 x	0.981 =	18.3	630	99.0
3	6	4.5	0.90 x 18.3 =	16.47 x	0.981 =	16.1	780	98.6
					AVG.	19.2	710	98.8

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC **TEST #** 1
ELEMENT # A1391874
MEMBRANE SHEET # 1
MEMBRANE I.D. # 1874-1

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/4/ 91
PRESSURE: 800 psi
FLOW RATE: 0.75 gpm
TEMPERATURE: 33.5 C
FEED CONDUCTIVITY: 57,000 umhos
FEED pH: 7.0

START TIME: 1540
FINISH TIME: 1640
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 4.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	8.4	2.10 x 18.3 =	38.43 x	0.835 =	32.1	510	99.1
2	3	8.0	2.00 x 18.3 =	36.60 x	0.835 =	30.6	550	99.0
3	5	8.4	2.10 x 18.3 =	38.43 x	0.835 =	32.1	475	99.2
					AVG.	31.6	512	99.1

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: BENZALKONIUM CHLORIDE **CONC.:** 0.5% **BUFFER:** HCl/NaHCO3 **pH:** 6.85

IMMERSION IN BIOCIDE: 9/26/ 91
TOTAL TIME IN BIOCIDE: 67 DAYS
REMOVAL FROM BIOCIDE: 12/2/91

TEST DATE: 12/2/ 91
PRESSURE: 800 psi
FLOW RATE: 0.71 gpm
TEMPERATURE: 26 C
FEED CONDUCTIVITY: 56,000 umhos
FEED pH: 7.8

START TIME: 1105
FINISH TIME: 1205
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: A.V.D.L.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	0.0	— x 18.3 =	— x	— =	—	—	—
2	4	0.0	— x 18.3 =	— x	— =	—	—	—
3	6	0.0	— x 18.3 =	— x	— =	—	—	—
					AVG.	—	—	—

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC TEST # 2
ELEMENT # A1391874
MEMBRANE SHEET # 3
MEMBRANE I.D. # 1874-2

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/5/91
PRESSURE: 800 psi
FLOW RATE: 0.7 gpm
TEMPERATURE: 33.5 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 7.0

START TIME: 1205
FINISH TIME: 1305
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 4.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	8.3	2.08 x 18.3 =	38.06 x	0.835 =	31.8	620	98.9
2	3	8.0	2.00 x 18.3 =	36.60 x	0.835 =	30.6	800	98.6
3	5	8.3	2.08 x 18.3 =	38.06 x	0.835 =	31.8	980	98.3
					AVG.	31.4	800	98.6

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: BENZALKONIUM CHLORIDE CONC.: 0.1% BUFFER: HCl/NaHCO3 pH: 7.3

IMMERSION IN BIOCIDE: 9/26/91
TOTAL TIME IN BIOCIDE: 67 DAYS
REMOVAL FROM BIOCIDE: 12/2/91

TEST DATE: 12/2/91
PRESSURE: 800 psi
FLOW RATE: 0.78 gpm
TEMPERATURE: 26 C
FEED CONDUCTIVITY: 56,000 umhos
FEED pH: 7.8

START TIME: 1415
FINISH TIME: 1515
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 30 min.
DATA TAKEN BY:

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	3.5	0.117 x 18.3 =	2.14 x	0.970 =	2.1	6800	87.9
2	4	4.6	0.153 x 18.3 =	2.80 x	0.970 =	2.7	4600	91.8
3	6	4.5	0.150 x 18.3 =	2.75 x	0.970 =	2.7	5200	90.7
					AVG.	2.5	5533	90.1

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC **TEST #** 3
ELEMENT # A139/874
MEMBRANE SHEET # 4
MEMBRANE I.D. # 1874-3

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/5/91
PRESSURE: 800 psi
FLOW RATE: 0.65 gpm
TEMPERATURE: 34.0 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 6.95-7.00

START TIME: 1410
FINISH TIME: 1510
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 4.0 min.
DATA TAKEN BY:

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	8.3	2.08 x 18.3 =	38.06x	0.830 =	31.6	520	99.1
2	3	8.35	2.09 x 18.3 =	38.25x	0.830 =	31.7	650	98.9
3	5	8.0	2.00 x 18.3 =	36.60x	0.830 =	30.4	480	99.2
					AVG.	31.2	550	99.1

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: BENZALKONIUM CHLORIDE **CONC.:** 0.01 % **BUFFER:** HCl/NaHCO3 **pH:** 6.80

IMMERSION IN BIOCIDE: 9/27/91
TOTAL TIME IN BIOCIDE: 68 DAYS
REMOVAL FROM BIOCIDE: 12/3/91

TEST DATE: 12/3/91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 26.5 C
FEED CONDUCTIVITY: 56,000 umhos
FEED pH: 7.8

START TIME: 1035
FINISH TIME: 1135
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 10 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	4.3	0.43 x 18.3 =	7.87x	0.955 =	7.5	4400	92.1
2	4	4.2	0.42 x 18.3 =	7.69x	0.955 =	7.3	3400	93.9
3	6	5.1	0.51 x 18.3 =	9.33x	0.955 =	8.9	5700	89.8
					AVG.	7.9	4500	91.9

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC **TEST #** 4
ELEMENT # A139/874
MEMBRANE SHEET # 5
MEMBRANE I.D. # 1874-4

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/5/91
PRESSURE: 800 psi
FLOW RATE: 0.65 gpm
TEMPERATURE: 33.5 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 7.5

START TIME: 1540
FINISH TIME: 1640
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY:

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	9.5	1.90 x 18.3 =	34.77 x	0.835 =	29.0	880	98.5
2	3	9.5	1.90 x 18.3 =	34.77 x	0.835 =	29.0	900	98.4
3	5	9.6	1.92 x 18.3 =	35.14 x	0.835 =	29.3	740	98.7
					AVG.	29.1	840	98.5

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: MEMSTOBE **CONC.:** 2% **BUFFER:** NONE **pH:** 5.5

IMMERSION IN BIOCIDE: 9/26/91
TOTAL TIME IN BIOCIDE: 68 DAYS
REMOVAL FROM BIOCIDE: 12/3/91

TEST DATE: 12/3/91
PRESSURE: 800 psi
FLOW RATE: 0.72 gpm
TEMPERATURE: 26.5 C
FEED CONDUCTIVITY: 56,000 umhos
FEED pH: 7.8

START TIME: 1420
FINISH TIME: 1520
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	6.1	1.22 x 18.3 =	22.33 x	0.955 =	21.3	350	99.4
2	4	5.8	1.16 x 18.3 =	21.23 x	0.955 =	20.3	380	99.3
3	6	6.0	1.20 x 18.3 =	21.96 x	0.955 =	21.0	480	99.1
					AVG.	20.9	403	99.3

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC **TEST #** 5
ELEMENT # A1391874
MEMBRANE SHEET # 6
MEMBRANE I.D. # 1874-5

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/6/ 91
PRESSURE: 800 psi
FLOW RATE: _____ gpm
TEMPERATURE: 32.6 C
FEED CONDUCTIVITY: 57,800 umhos
FEED pH: 7.5

START TIME: 0830
FINISH TIME: 0930
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 4.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	7.9	1.97 x 18.3 =	36.05 x	0.850 =	30.6	600	99.0
2	3	7.7	1.93 x 18.3 =	35.32 x	0.850 =	30.0	470	99.2
3	5	7.6	1.90 x 18.3 =	34.77 x	0.850 =	29.5	550	99.0
					AVG.	30.0	540	99.1

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: PROGARD **CONC.:** 20% **BUFFER:** NONE **pH:** 5.3

IMMERSION IN BIOCIDE: 9/26/ 91
TOTAL TIME IN BIOCIDE: 69 DAYS
REMOVAL FROM BIOCIDE: 12/4/91

TEST DATE: 12/4/ 91
PRESSURE: 800 psi
FLOW RATE: 0.73 gpm
TEMPERATURE: 25.0 C
FEED CONDUCTIVITY: 56,000 umhos
FEED pH: 7.8

START TIME: 0825
FINISH TIME: 0925
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2*	7.4	1.48 x 18.3 =	27.08 x	1.00 =	27.1	9000	83.9
2	4*	6.2	1.24 x 18.3 =	22.69 x	1.00 =	22.7	3400	93.9
3	6*	6.0	1.20 x 18.3 =	21.96 x	1.00 =	22.0	840	98.5
					AVG.	23.9	4413	92.1

*MEMBRANE SURFACE SHOWED HEAVY DYE UPTAKE. MEMBRANES WERE DAMAGED. THIS TEST SHOULD BE REPEATED.

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC TEST # 6
ELEMENT # A1391874
MEMBRANE SHEET # 7
MEMBRANE I.D. # 1874-6

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/6/91
PRESSURE: 800 psi
FLOW RATE: 0.67 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 7.6

START TIME: 0955
FINISH TIME: 1055
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	9.3	1.86 x 18.3 =	34.04 x	0.840 =	28.6	530	99.1
2	3	9.35	1.87 x 18.3 =	34.22 x	0.840 =	28.7	700	98.8
3	5	9.5	1.90 x 18.3 =	34.77 x	0.840 =	29.2	670	98.8
					AVG.	28.8	633	98.9

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SUBSTITUTED ISOTHIOZOLINONE CONC.: 0.5% BUFFER: HCl/NaHCO$_3$ pH: 7.2

IMMERSION IN BIOCIDE: 9/26/91
TOTAL TIME IN BIOCIDE: 69 DAYS
REMOVAL FROM BIOCIDE: 12/4/91

TEST DATE: 12/4/91
PRESSURE: 800 psi
FLOW RATE: 0.72 gpm
TEMPERATURE: 25.5 C
FEED CONDUCTIVITY: 56,000 umhos
FEED pH: 7.8

START TIME: 0940
FINISH TIME: 1040
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	6.6	1.32 x 18.3 =	24.16 x	0.985 =	23.8	675	98.8
2	4	6.5	1.30 x 18.3 =	23.77 x	0.985 =	23.4	490	99.1
3	6	6.9	1.38 x 18.3 =	25.25 x	0.985 =	24.9	670	98.8
					AVG.	24.0	612	98.9

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC TEST # 7
ELEMENT # A1391874
MEMBRANE SHEET # 8
MEMBRANE I.D. # 1874-7

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/6/ 91
PRESSURE: 800 psi
FLOW RATE: 0.77 gpm
TEMPERATURE: 33.5 C
FEED CONDUCTIVITY: 58000 umhos
FEED pH: 7.6

START TIME: 1355
FINISH TIME: 1455
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 4.0 min.

DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	8.2	2.05 x 18.3 = 37.51 x		0.835 =	31.3	520	99.1
2	3	8.1	2.03 x 18.3 = 37.15 x		0.835 =	31.0	520	99.1
3	5	7.75	1.94 x 18.3 = 35.50 x		0.835 =	29.6	580	99.0
					AVG.	30.6	540	99.1

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SUBSTITUTED ISOTHIAZOLINONE CONC.: 0.13% BUFFER: HCl/NaHCO3 pH: 7.1

IMMERSION IN BIOCIDE: 9/26/ 91
TOTAL TIME IN BIOCIDE: 69 DAYS

REMOVAL FROM BIOCIDE: 12/4/91

TEST DATE: 12/4/ 91
PRESSURE: 800 psi
FLOW RATE: 0.75 gpm
TEMPERATURE: 26.5 C
FEED CONDUCTIVITY: 56,000 umhos
FEED pH: 7.8

START TIME: 1325
FINISH TIME: 1425
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.

DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	7.0	1.40 x 18.3 = 25.62 x		0.955 =	24.5	920	98.3
2	4	6.6	1.32 x 18.3 = 24.16 x		0.955 =	23.1	680	98.8
3	6	6.4	1.28 x 18.3 = 23.42 x		0.955 =	22.4	480	99.1
					AVG.	23.3	693	98.7

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC TEST # 8
ELEMENT # A1391874
MEMBRANE SHEET # 9
MEMBRANE I.D. # 1874-8

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/6/ 91
PRESSURE: 800 psi
FLOW RATE: 0.65 gpm
TEMPERATURE: 33.5 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 5.7

START TIME: 1523
FINISH TIME: 1623
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	9.45	1.89 x 18.3 =	34.59 x	0.835 =	28.9	460	99.2
2	3	9.3	1.86 x 18.3 =	34.04 x	0.835 =	28.4	450	99.2
3	5	9.3	1.86 x 18.3 =	34.04 x	0.835 =	28.4	480	99.2
					AVG.	28.6	463	99.2

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SUBSTITUTED ISOTHIAZOLINONE CONC.: 0.01% BUFFER: HCl/NaHCO3 pH: 7.4

IMMERSION IN BIOCIDE: 9/26/ 91
TOTAL TIME IN BIOCIDE: 69 DAYS
REMOVAL FROM BIOCIDE: 12/4/91

TEST DATE: 12/4/ 91
PRESSURE: 800 psi
FLOW RATE: 0.65 gpm
TEMPERATURE: 26.0 C
FEED CONDUCTIVITY: 56,000 umhos
FEED pH: 7.8

START TIME: 1555
FINISH TIME: 1655
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	7.0	1.40 x 18.3 =	25.62 x	0.970 =	24.9	670	98.8
2	4	6.5	1.30 x 18.3 =	23.79 x	0.970 =	23.1	650	98.8
3	6	—	— x 18.3 =	— x	— =	—	—	—
					AVG.	24.0	660	98.8

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC **TEST #** 9
ELEMENT # A1391874
MEMBRANE SHEET # 10
MEMBRANE I.D. # 1874-9

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/9/91
PRESSURE: 800 psi
FLOW RATE: 0.75 gpm
TEMPERATURE: 34 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 7.0

START TIME: 1540
FINISH TIME: 1640
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 4.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	8.4	2.10 x 18.3 =	38.43x	0.830 =	31.9	510	99.1
2	3	8.0	2.00 x 18.3 =	36.60x	0.830 =	30.	550	99.1
3	5	8.4	2.10 x 18.3 =	38.43x	0.830 =	31.9	475	99.2
					AVG.	31.4	512	99.1

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: BCDMH **CONC.:** 100 mg/L **BUFFER:** $HCl/NaHCO_3$ **pH:** 6.5

IMMERSION IN BIOCIDE: 9/26/91
TOTAL TIME IN BIOCIDE: 70 DAYS
REMOVAL FROM BIOCIDE: 12/5/91

TEST DATE: 12/5/91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 25.5 C
FEED CONDUCTIVITY: 56,000 umhos
FEED pH: 7.8

START TIME: 0925
FINISH TIME: 1025
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	6.0	1.20 x 18.3 =	21.96x	0.985 =	21.6	480	99.1
2	4	6.0	1.20 x 18.3 =	21.96x	0.985 =	21.6	480	99.1
3	6	5.7	1.14 x 18.3 =	20.86x	0.985 =	20.5	390	99.3
					AVG.	21.2	450	99.2

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC **TEST #** 10
ELEMENT # A1391874
MEMBRANE SHEET # 11
MEMBRANE I.D. # 1874-10

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/9/ 91
PRESSURE: 800 psi
FLOW RATE: 0.67 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 8.0

START TIME: 1205
FINISH TIME: 1305
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.L.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	9.1	1.82 x 18.3 = 33.31 x	0.840 =		28.0	600	99.0
2	3	9.1	1.82 x 18.3 = 33.31 x	0.840 =		28.0	700	98.8
3	5	9.2	1.84 x 18.3 = 33.67 x	0.840 =		28.3	660	98.9
					AVG.	28.1	653	98.9

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: BCDMH **CONC.:** 10 mg/L **BUFFER:** $HCl/NaHCO_3$ **pH:** 6.4

IMMERSION IN BIOCIDE: 9/26/ 91
TOTAL TIME IN BIOCIDE: 70 DAYS
REMOVAL FROM BIOCIDE: 12/5/91

TEST DATE: 12/5/ 91
PRESSURE: 800 psi
FLOW RATE: 0.65 gpm
TEMPERATURE: 26.0 C
FEED CONDUCTIVITY: 56,000 umhos
FEED pH: 7.8

START TIME: 1145
FINISH TIME: 1245
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 6.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	6.9	1.15 x 18.3 = 21.05 x	0.970 =		20.4	590	98.9
2	4	6.1	1.02 x 18.3 = 18.67 x	0.970 =		18.1	480	99.1
3	6	6.4	1.07 x 18.3 = 19.52 x	0.970 =		18.9	560	99.0
					AVG.	19.1	543	99.0

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC **TEST #** 11
ELEMENT # A139 1874
MEMBRANE SHEET # 12
MEMBRANE I.D. # 1874-11

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/9/ 91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 34.5 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH:

START TIME: 1325
FINISH TIME: 1425
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 4.0 min.
DATA TAKEN BY: K.L.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	7.5	1.87 x 18.3 =	34.22 x	0.825 =	28.2	530	99.1
2	3	7.6	1.90 x 18.3 =	34.77 x	0.825 =	28.7	580	99.0
3	5	7.1	1.77 x 18.3 =	32.39 x	0.825 =	26.7	550	99.1
					AVG.	27.9	553	99.1

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: BCDMH **CONC.:** 1 mg/L **BUFFER:** HCl/$NaHCO_3$ **pH:** 7.1

IMMERSION IN BIOCIDE: 9/26/ 91
TOTAL TIME IN BIOCIDE: 70 DAYS
REMOVAL FROM BIOCIDE: 12/5/91

TEST DATE: 12/5/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 26.0 C
FEED CONDUCTIVITY: 56,000 umhos
FEED pH: 7.8

START TIME: 1310
FINISH TIME: 1410
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	5.3	1.06 x 18.3 =	19.40 x	0.970 =	18.8	750	98.7
2	4	5.7	1.14 x 18.3 =	20.86 x	0.970 =	20.2	770	98.6
3	6	5.6	1.12 x 18.3 =	20.50 x	0.970 =	19.9	760	98.6
					AVG.	19.6	760	98.6

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC **TEST #** 12
ELEMENT # A1391874
MEMBRANE SHEET # 13
MEMBRANE I.D. # 1874-12

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/9/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 34.5 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH:

START TIME: 1445
FINISH TIME: 1545
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 4.0 min.
DATA TAKEN BY: K.L.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	7.85	1.96 x 18.3 =	35.87 x	0.825 =	29.6	600	99.0
2	3	7.65	1.91 x 18.3 =	34.95 x	0.825 =	28.8	640	98.9
3	5	7.30	1.83 x 18.3 =	33.40 x	0.825 =	27.5	640	98.9
					AVG.	28.6	627	98.9

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: BROMONITRO-PROPANEDIOL **CONC.:** 0.5% **BUFFER:** HCl/$NaHCO_3$ **pH:** 4.0

IMMERSION IN BIOCIDE: 9/27/ 91
TOTAL TIME IN BIOCIDE: 69 DAYS
REMOVAL FROM BIOCIDE: 12/5/91

TEST DATE: 12/5/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 25.0 C
FEED CONDUCTIVITY: 56,000 umhos
FEED pH: 7.8

START TIME: 0805
FINISH TIME: 0905
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	3.6	0.72 x 18.3 =	13.18 x	1.00 =	13.2	740	98.7
2	4	3.4	0.68 x 18.3 =	12.44 x	1.00 =	12.4	580	99.0
3	6	3.7	0.74 x 18.3 =	13.51 x	1.00 =	13.5	620	98.9
					AVG.	13.0	647	98.9

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC **TEST #** 13
ELEMENT # A1321874
MEMBRANE SHEET # 14
MEMBRANE I.D. # 1874-13

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/10/91
PRESSURE: 800 psi
FLOW RATE: 0.72 gpm
TEMPERATURE: 32 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 7.7

START TIME: 0930
FINISH TIME: 1030
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	9.5	1.90 x 18.3 =	34.77 x	0.850 =	29.5	780	98.7
2	3	9.1	1.82 x 18.3 =	33.31 x	0.850 =	28.3	720	98.7
3	5	9.0	1.80 x 18.3 =	32.94 x	0.850 =	28.0	700	98.8
					AVG.	28.3	733	98.7

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: BROMONITRO-PROPANEDIOL **CONC.:** 0.10% **BUFFER:** HCl/NaHCO3 **pH:** 6.0

IMMERSION IN BIOCIDE: 9/27/91
TOTAL TIME IN BIOCIDE: 70 DAYS
REMOVAL FROM BIOCIDE: 12/6/91

TEST DATE: 12/6/91
PRESSURE: 800 psi
FLOW RATE: 0.76 gpm
TEMPERATURE: 25.5 C
FEED CONDUCTIVITY: 56,000 umhos
FEED pH: 7.8

START TIME: 1035
FINISH TIME: 1135
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 6.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	4.5	— x 18.3 =	— x	— =	—	2300	—
2	4	4.3	0.717 x 18.3 =	13.12 x	0.985 =	12.9	510	99.1
3	6	4.4	0.733 x 18.3 =	13.41 x	0.985 =	13.2	800	98.6
					AVG.	13.1	655	98.9

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC TEST # 14
ELEMENT # A1391874
MEMBRANE SHEET # 15
MEMBRANE I.D. # 1874-19

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/10/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 7.7

START TIME: 1100
FINISH TIME: 1200
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	9.5	1.90 x 18.3 = 34.77 x		0.840 =	29.2	520	99.1
2	3	9.4	1.88 x 18.3 = 34.40 x		0.840 =	28.9	570	99.0
3	5	9.4	1.88 x 18.3 = 34.40 x		0.840 =	28.9	520	99.1
					AVG.	29.0	537	99.1

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: BROMONITRO-PROPANEDIOL CONC.: 0.01 % BUFFER: HCl/NaHCO3 pH: 6.3

IMMERSION IN BIOCIDE: 9/27/ 91
TOTAL TIME IN BIOCIDE: 70 DAYS
REMOVAL FROM BIOCIDE: 12/6/91

TEST DATE: 12/6/ 91
PRESSURE: 800 psi
FLOW RATE: 0.72 gpm
TEMPERATURE: 26.0 C
FEED CONDUCTIVITY: 54,000 umhos
FEED pH: 7.8

START TIME: 1405
FINISH TIME: 1505
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	4.8	— x 18.3 = — x		— =	—	2200	—
2	4	4.5	0.90 x 18.3 = 16.47 x		0.97 =	16.0	1400	97.5
3	6	4.9	0.98 x 18.3 = 17.93 x		0.97 =	17.4	750	98.7
					AVG.	16.7	1075	98.1

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC **TEST #** 15
ELEMENT # A1391874
MEMBRANE SHEET # 16
MEMBRANE I.D. # 1879-15

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/10/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 7.7

START TIME: 1420
FINISH TIME: 1520
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	9.2	1.84 x 18.3 =	33.67 x	0.840 =	28.3	880	98.5
2	3	9.2	1.84 x 18.3 =	33.67 x	0.840 =	28.3	500	99.1
3	5	8.9	1.78 x 18.3 =	32.57 x	0.840 =	27.3	620	98.9
					AVG.	28.0	667	98.8

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: CETYTRIMETHAMMONIUM P-TOLUENE SULFONATE **CONC.:** 0.5% **BUFFER:** HCl/NaHCO3 **pH:** 7.9

IMMERSION IN BIOCIDE: 9/24/ 91
TOTAL TIME IN BIOCIDE: 76 DAYS
REMOVAL FROM BIOCIDE: 12/9/91

TEST DATE: 12/9/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 25.0 C
FEED CONDUCTIVITY: 56,000 umhos
FEED pH: 8.7

START TIME: 0905
FINISH TIME: 1005
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: A.V.D.L.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	2.6	0.52 x 18.3 =	9.52 x	1.00 =	9.5	1800	96.8
2	4	2.5	0.50 x 18.3 =	9.15 x	1.00 =	9.1	760	98.6
3	6	2.4	0.48 x 18.3 =	8.78 x	1.00 =	8.8	1500	97.3
					AVG.	9.1	1353	97.6

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC TEST # 16
ELEMENT # A1391874
MEMBRANE SHEET # 17
MEMBRANE I.D. # 1874-16

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/10/ 91
PRESSURE: 800 psi
FLOW RATE: 0.64 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 7.6

START TIME: 1545
FINISH TIME: 1645
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	9.3	1.86 x 18.3 =	34.04 x	0.840 =	28.6	770	98.7
2	3	9.3	1.86 x 18.3 =	34.04 x	0.840 =	28.6	520	99.1
3	5	9.2	1.84 x 18.3 =	33.67 x	0.840 =	28.3	690	98.8
					AVG.	28.5	660	98.9

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: CETYTRIMETHAMMONIUM p-TOLUENE SULFONATE CONC.: 0.1% BUFFER: HCl/NaHCO3 pH: 8.5

IMMERSION IN BIOCIDE: 9/24/ 91
TOTAL TIME IN BIOCIDE: 76 DAYS
REMOVAL FROM BIOCIDE: 12/9/91

TEST DATE: 12/9/ 91
PRESSURE: 800 psi
FLOW RATE: 0.67 gpm
TEMPERATURE: 25.5 C
FEED CONDUCTIVITY: 56,000 umhos
FEED pH: 8.7

START TIME: 1145
FINISH TIME: 1245
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 8.0 min.
DATA TAKEN BY: AVDL.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	4.2	0.525 x 18.3 =	9.61 x	0.985 =	9.5	1100	98.0
2	4	4.1	0.513 x 18.3 =	9.39 x	0.985 =	9.2	1200	97.9
3	6	3.6	0.450 x 18.3 =	8.24 x	0.985 =	8.1	1100	98.0
					AVG.	8.9	1133	98.0

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC TEST # 17
ELEMENT # A1391874
MEMBRANE SHEET # 18
MEMBRANE I.D. # 1874-17

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/11/91
PRESSURE: 800 psi
FLOW RATE: 0.67 gpm
TEMPERATURE: 32 C
FEED CONDUCTIVITY: 59,000 umhos
FEED pH: 7.8

START TIME: 0825
FINISH TIME: 0925
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: A.V.D.L.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	9.2	1.84 x 18.3 =	33.67 x	0.85 =	28.6	830	98.6
2	3	9.3	1.86 x 18.3 =	34.04 x	0.85 =	28.9	810	98.6
3	5	9.2	1.84 x 18.3 =	33.67 x	0.85 =	28.6	570	99.0
					AVG.	28.7	737	98.7

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: CETYTRIMETHAMMONIUM P-TOLUENE SULFONATE CONC.: 0.01% BUFFER: HCl/NaHCO3 pH:

IMMERSION IN BIOCIDE: 9/27/91
TOTAL TIME IN BIOCIDE: 75 DAYS
REMOVAL FROM BIOCIDE: 12/11/91

TEST DATE: 12/11/91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 26.0 C
FEED CONDUCTIVITY: 55,000 umhos
FEED pH: 7.7

START TIME: 1055
FINISH TIME: 1155
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	2.6	0.52 x 18.3 =	9.52 x	0.970 =	9.2	1200	97.8
2	4	2.7	0.54 x 18.3 =	9.88 x	0.970 =	9.6	960	98.3
3	6	2.6	0.52 x 18.3 =	9.52 x	0.970 =	9.2	700	98.7
					AVG.	9.3	953	98.3

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC TEST # 19
ELEMENT # A1319067 (2.5" ELEMENT)
MEMBRANE SHEET # 9067-18
MEMBRANE I.D. # 9067-19

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/23/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 32.5 C
FEED CONDUCTIVITY: 59,000 umhos
FEED pH: 7.7

START TIME: 0957
FINISH TIME: 1057
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY:

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	1	7.7	1.54 x 18.3 =	28.18 x	0.845	=	23.8	760	98.7
2	3	8.5	1.70 x 18.3 =	31.11 x	0.845	=	26.3	700	98.8
3	5	8.2	1.64 x 18.3 =	30.01 x	0.845	=	25.3	480	99.2
					AVG.		25.1	647	98.9

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SODIUM BENZOATE CONC.: 0.5% BUFFER: HCl/NaHCO3 pH: 5.4

IMMERSION IN BIOCIDE: 9/27/ 91
TOTAL TIME IN BIOCIDE: 75 DAYS
REMOVAL FROM BIOCIDE: 12/11/91

TEST DATE: 12/11/ 91
PRESSURE: 800 psi
FLOW RATE: 0.75 gpm
TEMPERATURE: 26.0 C
FEED CONDUCTIVITY: 55,000 umhos
FEED pH: 7.7

START TIME: 1400
FINISH TIME: 1503
ELAPSED TIME: 1.05 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	2	5.2	1.04 x 18.3 =	19.03 x	0.970	=	18.5	930	98.3
2	4	5.5	1.10 x 18.3 =	20.13 x	0.970	=	19.5	1200	97.8
3	6	5.3	1.06 x 18.3 =	19.40 x	0.970	=	18.8	500	99.1
					AVG.		18.9	877	98.4

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC TEST # 21
ELEMENT # A13190167 (2.5" ELEMENT)
MEMBRANE SHEET # 9067-2B
MEMBRANE I.D. # 9067-21

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/22/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 52,000 umhos
FEED pH: 7.7

START TIME: 1240
FINISH TIME: 1340
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY:

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	7.7	1.54 x 18.3 =	28.18 x	0.840 =	23.7	790	98.7
2	3	8.2	1.64 x 18.3 =	30.01 x	0.840 =	25.2	560	99.1
3	5	8.1	1.62 x 18.3 =	29.65 x	0.840 =	24.9	670	98.9
					AVG.	24.6	673	98.9

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SODIUM BENZOATE CONC.: 0.1% BUFFER: HCl/NaHCO3 pH: 6.35

IMMERSION IN BIOCIDE: 9/25/ 91
TOTAL TIME IN BIOCIDE: 79 DAYS
REMOVAL FROM BIOCIDE: 12/13/91

TEST DATE: 12/13/ 91
PRESSURE: 800 psi
FLOW RATE: 0.71 gpm
TEMPERATURE: 25.0 C
FEED CONDUCTIVITY: 55,000 umhos
FEED pH: 8.3

START TIME: 0925
FINISH TIME: 1025
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: A.V.D.L.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	6.8	1.36 x 18.3 =	24.89 x	1.00 =	24.9	1800	96.7
2	4	6.3	1.26 x 18.3 =	23.06 x	1.00 =	23.1	1300	97.6
3	6	6.1	1.22 x 18.3 =	22.33 x	1.00 =	22.3	910	98.3
					AVG.	23.4	1337	97.5

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC TEST # 23
ELEMENT # A1319067 (2.5" ELEMENT)
MEMBRANE SHEET # 9067-3B
MEMBRANE I.D. # 9067-23

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/24/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 32 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.7

START TIME: 0810
FINISH TIME: 0920
ELAPSED TIME: 1.2 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	7.1	1.42 x 18.3 =	25.99 x	0.850 =	22.1	780	98.7
2	3	7.7	1.54 x 18.3 =	28.18 x	0.850 =	23.9	720	98.8
3	5	7.8	1.56 x 18.3 =	28.55 x	0.850 =	24.3	530	99.1
					AVG.	23.4	677	98.9

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SODIUM BENZOATE CONC.: 0.01% BUFFER: HCl/NaHCO3 pH: 5.95

IMMERSION IN BIOCIDE: 9/25/ 91
TOTAL TIME IN BIOCIDE: 79 DAYS
REMOVAL FROM BIOCIDE: 12/13/91

TEST DATE: 12/13/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 25.5 C
FEED CONDUCTIVITY: 55,000 umhos
FEED pH: 8.3

START TIME: 1145
FINISH TIME: 1245
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: A.V.D.L.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	5.9	1.18 x 18.3 =	21.59 x	0.985 =	21.3	2200	96.0
2	4	5.5	1.10 x 18.3 =	20.13 x	0.985 =	19.8	1200	97.8
3	6	6.0	1.20 x 18.3 =	21.96 x	0.985 =	21.6	3300	94.0
					AVG.	20.9	2233	95.9

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC TEST # 25
ELEMENT # A13190167 (2.5" ELEMENT)
MEMBRANE SHEET # 9067-48
MEMBRANE I.D. # 9067-25

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/24/ 91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.7

START TIME: 1115
FINISH TIME: 1215
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	8.0	1.60 x 18.3 = 29.28 x	0.840 =		24.6	600	99.0
2	3	7.8	1.56 x 18.3 = 28.55 x	0.840 =		24.0	530	99.1
3	5	7.9	1.58 x 18.3 = 28.91 x	0.840 =		24.3	600	99.0
					AVG.	24.3	577	99.0

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: EDTA CONC.: 0.5% BUFFER: HCl/NaHCO3 pH: 5.15

IMMERSION IN BIOCIDE: 9/25/ 91
TOTAL TIME IN BIOCIDE: 79 DAYS
REMOVAL FROM BIOCIDE: 12/13/91

TEST DATE: 12/13/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 26.0 C
FEED CONDUCTIVITY: 55,000 umhos
FEED pH: 8.3

START TIME: 1255
FINISH TIME: 1355
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: A.V.D.L.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	5.9	1.18 x 18.3 = 21.59 x	0.970 =		20.9	720	98.7
2	4	5.35	1.07 x 18.3 = 19.58 x	0.970 =		19.0	560	99.0
3	6	5.1	1.02 x 18.3 = 18.67 x	0.970 =		18.1	540	99.0
					AVG.	19.3	607	98.9

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC TEST # 27
ELEMENT # A1319067 (2.5" ELEMENT)
MEMBRANE SHEET # 9067-5B
MEMBRANE I.D. # 9067-27

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/24/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.7

START TIME: 1400
FINISH TIME: 1515
ELAPSED TIME: 1.25 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	7.6	1.52 x 18.3 = 27.82 x	0.840 =		23.4	770	98.7
2	3	7.9	1.58 x 18.3 = 28.91 x	0.840 =		24.3	780	98.7
3	5	8.2	1.64 x 18.3 = 30.01 x	0.840 =		25.2	565	99.1
					AVG.	24.3	705	98.8

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: EDTA CONC.: 0.1% BUFFER: HCl/NaHCO3 pH: 5.5

IMMERSION IN BIOCIDE: 9/25/ 91
TOTAL TIME IN BIOCIDE: 82 DAYS
REMOVAL FROM BIOCIDE: 12/16/91

TEST DATE: 12/16/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 24.5 C
FEED CONDUCTIVITY: 55,000 umhos
FEED pH: 7.85

START TIME: 1015
FINISH TIME: 1115
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 8.0 min.
DATA TAKEN BY: A.V.D.L.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	10.4	1.30 x 18.3 = 23.79 x	1.01 =		24.0	460	99.2
2	4	9.7	1.21 x 18.3 = 22.14 x	1.01 =		22.4	940	98.3
3	6	10.0	1.25 x 18.3 = 22.87 x	1.01 =		23.1	440	99.2
					AVG.	23.2	613	98.9

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC **TEST #** 29
ELEMENT # A1319067 (2.5" ELEMENT)
MEMBRANE SHEET # 9067-6B
MEMBRANE I.D. # 9067-29

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/25/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 32.5 C
FEED CONDUCTIVITY: 61,000 umhos
FEED pH: 7.3

START TIME: 0805
FINISH TIME: 0905
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	1	7.8	1.56 x 18.3 =	28.55 x	0.845	=	24.1	820	98.7
2	3	8.2	1.64 x 18.3 =	30.01 x	0.845	=	25.3	910	98.5
3	5	8.3	1.66 x 18.3 =	30.38 x	0.845	=	25.7	740	98.8
					AVG.		25.0	823	98.7

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: EDTA **CONC.:** 0.01% **BUFFER:** HCl/NaHCO3 **pH:** 4.95

IMMERSION IN BIOCIDE: 9/25/ 91
TOTAL TIME IN BIOCIDE: 82 DAYS
REMOVAL FROM BIOCIDE: 12/16/91

TEST DATE: 12/16/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 25.5 C
FEED CONDUCTIVITY: 55,000 umhos
FEED pH: 7.85

START TIME: 1300
FINISH TIME: 1400
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 7.0 min.
DATA TAKEN BY: A.V.D.L.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	2	8.7	1.24 x 18.3 =	22.69 x	0.985	=	22.3	760	98.6
2	4	8.4	1.20 x 18.3 =	21.96 x	0.985	=	21.6	610	98.9
3	6	8.4	1.20 x 18.3 =	21.96 x	0.985	=	21.6	560	99.0
					AVG.		21.8	643	98.8

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC TEST # 34
ELEMENT # A1318722 (2.5" ELEMENT)
MEMBRANE SHEET # 8722-9T
MEMBRANE I.D. # 8722-34

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/26/ 91
PRESSURE: 800 psi
FLOW RATE: 0.63 gpm
TEMPERATURE: 32.5 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.2

START TIME: 1000
FINISH TIME: 1100
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY:

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	1	8.1	1.62 x 18.3 =	29.65 x	0.845	=	25.1	500	99.2
2	3	7.7	1.54 x 18.3 =	28.18 x	0.845	=	23.8	470	99.2
3	5	7.8	1.56 x 18.3 =	28.55 x	0.845	=	24.1	710	98.8
						AVG.	24.3	560	99.1

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SODIUM BENZOATE EDTA (50:50) CONC.: 0.5% BUFFER: HCl/NaHCO3 pH:

IMMERSION IN BIOCIDE: 10/3/ 91
TOTAL TIME IN BIOCIDE: 74 DAYS
REMOVAL FROM BIOCIDE: 12/16/91

TEST DATE: 12/17/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 25.0 C
FEED CONDUCTIVITY: 55,000 umhos
FEED pH: 7.85

START TIME: 0900
FINISH TIME: 1000
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 7.0 min.
DATA TAKEN BY:

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	2	8.3	1.19 x 18.3 =	21.78 x	1.00	=	21.8	420	99.2
2	4	8.1	1.16 x 18.3 =	21.23 x	1.00	=	21.2	480	99.1
3	6	8.0	1.14 x 18.3 =	20.86 x	1.00	=	20.9	440	99.2
						AVG.	21.3	447	99.2

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC TEST # 35
ELEMENT # A1318722 (2.5" ELEMENT)
MEMBRANE SHEET # 8722-9B
MEMBRANE I.D. # 8722-35

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/26/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 61,000 umhos
FEED pH: 7.2

START TIME: 1150
FINISH TIME: 1250
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY:

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	8.2	— x 18.3 = —	x 0.840 =		—	1600	—
2	3	7.7	1.54 x 18.3 = 28.18	x 0.840 =		23.7	1600	98.9
3	5	7.8	1.56 x 18.3 = 28.55	x 0.840 =		24.0	1620	99.0
				AVG.		23.9	1640	98.9

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SODIUM BENZOATE EDTA (50:50) CONC.: 0.05% BUFFER: $HCl/NaHCO_3$ pH: 5.0

IMMERSION IN BIOCIDE: 10/3/ 91
TOTAL TIME IN BIOCIDE: 75 DAYS
REMOVAL FROM BIOCIDE: 12/17/91

TEST DATE: 12/17/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 25.0 C
FEED CONDUCTIVITY: 55,000 umhos
FEED pH: 7.45

START TIME: 1225
FINISH TIME: 1325
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 7.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	8.4	1.20 x 18.3 = 21.96	x 1.00 =		22.0	420	99.2
2	4	8.2	1.17 x 18.3 = 21.41	x 1.00 =		21.4	520	99.1
3	6	7.5	1.07 x 18.3 = 19.58	x 1.00 =		19.6	700	98.7
				AVG.		21.0	547	99.0

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC TEST # 36
ELEMENT # A1318722 (2.5" ELEMENT)
MEMBRANE SHEET # 8722-10T
MEMBRANE I.D. # 8722-36

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/26/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.1

START TIME: 1320
FINISH TIME: 1420
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY:

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	7.7	— x 18.3 = —	x	0.840 =	—	1200	—
2	3	8.0	1.60 x 18.3 = 29.28	x	0.840 =	24.6	530	99.1
3	5	7.9	1.58 x 18.3 = 28.91	x	0.840 =	24.3	620	99.0
					AVG.	24.5	575	99.1

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SODIUM BENZOATE EDTA (50:50) CONC.: 0.01 % BUFFER: $HCl/NaHCO_3$ pH: 5.0

IMMERSION IN BIOCIDE: 10/3/91
TOTAL TIME IN BIOCIDE: 75 DAYS
REMOVAL FROM BIOCIDE: 12/17/91

TEST DATE: 12/17/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 25.0 C
FEED CONDUCTIVITY: 55,000 umhos
FEED pH: 7.45

START TIME: 2025
FINISH TIME: 2125
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 7.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	8.5	1.21 x 18.3 = 22.14	x	1.00 =	22.1	510	99.1
2	4	8.3	1.19 x 18.3 = 21.78	x	1.00 =	21.8	420	99.2
3	6	8.5	1.21 x 18.3 = 22.14	x	1.00 =	—	1800	—
					AVG.	21.9	465	99.1

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC TEST # 37
ELEMENT # A1818722 (2.5" ELEMENT)
MEMBRANE SHEET # 8722-10B
MEMBRANE I.D. # 8722-37

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/27/ 91
PRESSURE: 800 psi
FLOW RATE: 0.607 gpm
TEMPERATURE: 32 C
FEED CONDUCTIVITY: 59,000 umhos
FEED pH: 6.8

START TIME: 0810
FINISH TIME: 0910
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.

DATA TAKEN BY: A.V.D.L.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	8.1	1.62 x 18.3 =	29.65 x	0.850 =	25.2	730	98.8
2	3	7.7	1.54 x 18.3 =	28.18 x	0.850 =	23.9	610	99.0
3	5	7.6	1.52 x 18.3 =	27.82 x	0.850 =	23.6	520	99.1
					AVG.	24.2	620	99.1

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: GLUTERALDEHYDE CONC.: 3.0 % BUFFER: $HCl/NaHCO_3$ pH: 5.10

IMMERSION IN BIOCIDE: 10/4/ 91
TOTAL TIME IN BIOCIDE: 75 DAYS

REMOVAL FROM BIOCIDE: 12/18/91

TEST DATE: 12/18/ 91
PRESSURE: 800 psi
FLOW RATE: 0.72 gpm
TEMPERATURE: 25.0 C
FEED CONDUCTIVITY: 55,000 umhos
FEED pH: 7.7

START TIME: 0950
FINISH TIME: 1050
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 30 min.

DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	1.8	0.06 x 18.3 =	1.10 x	1.00 =	1.1	6400	88.4
2	4	2.0	0.07 x 18.3 =	1.28 x	1.00 =	1.3	5000	90.9
3	6	1.9	0.06 x 18.3 =	1.10 x	1.00 =	1.1	7000	87.3
					AVG.	1.2	6133	88.9

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC TEST # 38
ELEMENT # A1318722 (2.5" ELEMENT)
MEMBRANE SHEET # 8722-11T
MEMBRANE I.D. # 8722-38

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/27/ 91
PRESSURE: 800 psi
FLOW RATE: 0.67 gpm
TEMPERATURE: 32.5 C
FEED CONDUCTIVITY: 59,000 umhos
FEED pH: 7.0

START TIME: 0930
FINISH TIME: 1030
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: A.V.D.L.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	1	8.1	1.62 x 18.3 =	29.65 x	0.850	=	25.2	540	99.1
2	3	7.9	1.58 x 18.3 =	28.91 x	0.850	=	24.6	1630	98.9
3	5	7.6	1.52 x 18.3 =	27.82 x	0.850	=	—	2300	—
						AVG.	24.9	586	99.0

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: GLUTERALDEHYDE CONC.: 1.0 % BUFFER: $HCl/NaHCO_3$ pH: 5.6

IMMERSION IN BIOCIDE: 10/4/ 91
TOTAL TIME IN BIOCIDE: 75 DAYS
REMOVAL FROM BIOCIDE: 12/18/91

TEST DATE: 12/18/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 25.5 C
FEED CONDUCTIVITY: 55,000 umhos
FEED pH: 7.7

START TIME: 1250
FINISH TIME: 1350
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 20 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	2	3.5	0.17 x 18.3 =	3.11 x	0.985	=	3.1	2100	96.2
2	4	3.2	0.16 x 18.3 =	2.93 x	0.985	=	2.9	2200	96.0
3	6	3.0	0.15 x 18.3 =	2.75 x	0.985	=	—	8000	—
						AVG.	3.0	2150	96.1

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC
TEST # 39
ELEMENT # A1318722 (2.5" ELEMENT)
MEMBRANE SHEET # 8722-11B
MEMBRANE I.D. # 8722-39

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/27/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 32.5 C
FEED CONDUCTIVITY: 41,000 umhos
FEED pH: 7.0

START TIME: 1105
FINISH TIME: 1205
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: A.V.D.L.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	7.55	1.51 x 18.3 =	27.63 x	0.850 =	23.5	560	99.1
2	3	7.8	1.56 x 18.3 =	28.55 x	0.850 =	24.3	460	99.2
3	5	7.9	1.58 x 18.3 =	28.91 x	0.850 =	24.6	590	99.0
					AVG.	24.1	537	99.1

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: GLUTERALDEHYDE CONC.: 0.5% BUFFER: $HCl/NaHCO_3$ pH: 5.9

IMMERSION IN BIOCIDE: 10/4/ 91
TOTAL TIME IN BIOCIDE: 75 DAYS
REMOVAL FROM BIOCIDE: 12/18/91

TEST DATE: 12/18/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 25.5 C
FEED CONDUCTIVITY: 55,000 umhos
FEED pH: 7.7

START TIME: 1540
FINISH TIME: 1640
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 15 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	4.0	0.27 x 18.3 =	4.94 x	0.985 =	4.9	980	98.2
2	4	4.0	0.27 x 18.3 =	4.94 x	0.985 =	4.9	660	98.8
3	6	3.6	0.24 x 18.3 =	4.39 x	0.985 =	4.3	1400	97.5
					AVG.	4.7	1013	98.2

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC TEST # 40
ELEMENT # A1318722 (2.5" ELEMENT)
MEMBRANE SHEET # 8722-12T
MEMBRANE I.D. # 8722-40

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/27/ 91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 61,000 umhos
FEED pH: 7.1

START TIME: 1225
FINISH TIME: 1325
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: A.V.D.L.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	1	7.8	1.56 x 18.3 =	28.55 x	0.840	=	24.0	660	98.9
2	3	7.9	1.58 x 18.3 =	28.91 x	0.840	=	24.3	500	99.2
3	5	7.8	1.56 x 18.3 =	28.55 x	0.840	=	24.0	620	99.0
					AVG.		24.1	593	99.0

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SODIUM BISULFITE/GLYCERINE CONC.: 1.0/20.0% BUFFER: $HCl/NaHCO_3$ pH: 7.1

IMMERSION IN BIOCIDE: 10/4/ 91
TOTAL TIME IN BIOCIDE: 76 DAYS
REMOVAL FROM BIOCIDE: 12/19/91

TEST DATE: 12/19/ 91
PRESSURE: 800 psi
FLOW RATE: 0.80 gpm
TEMPERATURE: 25.0 C
FEED CONDUCTIVITY: 55,000 umhos
FEED pH: 7.6

START TIME: 1545
FINISH TIME: 1645
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	2	7.2	1.44 x 18.3 =	26.35 x	1.00	=	26.3	780	98.6
2	4	7.0	1.40 x 18.3 =	25.62 x	1.00	=	25.6	790	98.6
3	6	7.1	1.42 x 18.3 =	25.99 x	1.00	=	26.0	670	98.8
					AVG.		26.0	747	98.7

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC TEST # 50
ELEMENT # A1318722
MEMBRANE SHEET # 8722-17
MEMBRANE I.D. # 8722-50

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/10/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 31 C
FEED CONDUCTIVITY: 61,000 umhos
FEED pH: 7.4

START TIME: 0925
FINISH TIME: 1025
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	7.6	1.52 x 18.3 = 27.82	x 0.795 =		22.1	520	99.1
2	3	7.6	1.52 x 18.3 = 27.82	x 0.795 =		22.1	360	99.4
3	5	7.3	1.46 x 18.3 = 26.72	x 0.795 =		21.2	520	99.1
					AVG.	21.8	467	99.2

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: CONTROL CONC.: DI WATER BUFFER: NA pH: 5.5

IMMERSION IN BIOCIDE: 10/11/ 91
TOTAL TIME IN BIOCIDE: 70 DAYS
REMOVAL FROM BIOCIDE: 12/20 91

TEST DATE: 12/20/ 91
PRESSURE: 800 psi
FLOW RATE: 0.78 gpm
TEMPERATURE: 24.5 C
FEED CONDUCTIVITY: 55,000 umhos
FEED pH: 7.7

START TIME: 0855
FINISH TIME: 0955
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	10.2	1.24 x 18.3 = 22.69	x 1.02 =		23.1	600	98.9
2	4	5.9	1.18 x 18.3 = 21.59	x 1.02 =		22.0	590	98.9
3	6	5.9	1.18 x 18.3 = 21.59	x 1.02 =		22.0	510	99.1
					AVG.	22.4	567	99.0

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC TEST # 51
ELEMENT # A1318722
MEMBRANE SHEET # 8722-18
MEMBRANE I.D. # 8722-51

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/10/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 32 C
FEED CONDUCTIVITY: 61,000 umhos
FEED pH: 7.4

START TIME: 1050
FINISH TIME: 1150
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	1	7.5	1.50 x 18.3 =	27.45 x	0.765	=	21.0	600	99.0
2	3	7.2	1.44 x 18.3 =	26.35 x	0.765	=	20.1	700	98.9
3	5	7.5	1.50 x 18.3 =	27.45 x	0.765	=	21.0	520	99.1
					AVG.		20.7	607	99.0

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: CONTROL CONC.: NA BUFFER: NA pH: 6.3

IMMERSION IN BIOCIDE: 10/11/ 91
TOTAL TIME IN BIOCIDE: 88 DAYS
REMOVAL FROM BIOCIDE: 1/7/91

TEST DATE: 1/7/ 91
PRESSURE: 800 psi
FLOW RATE: 0.72 gpm
TEMPERATURE: 25 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 7.7

START TIME: 1335
FINISH TIME: 1435
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	2	6.3	1.26 x 18.3 =	23.06 x	1.00	=	23.1	600	99.0
2	4	6.5	1.30 x 18.3 =	23.77 x	1.00	=	23.8	540	99.1
3	6	6.2	1.24 x 18.3 =	22.68 x	1.00	=	22.7	580	99.0
					AVG.		23.2	573	99.0

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC TEST # 52
ELEMENT # A1318722
MEMBRANE SHEET # 8722-19
MEMBRANE I.D. # 8722-52

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/10/ 91
PRESSURE: 800 psi
FLOW RATE: 0.7 gpm
TEMPERATURE: 32 C
FEED CONDUCTIVITY: 61,000 umhos
FEED pH: 7.4

START TIME: 1225
FINISH TIME: 1345
ELAPSED TIME: 1.3 hr.
COLLECTION TIME: 6.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	1	9.0	1.50 x 18.3 =	27.45 x	0.765	=	21.0	900	98.5
2	3	8.8	1.47 x 18.3 =	26.90 x	0.765	=	20.6	600	99.0
3	5	8.8	1.47 x 18.3 =	26.90 x	0.765	=	20.6	560	99.1
						AVG.	20.7	687	98.9

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: CONTROL CONC.: NA BUFFER: NA pH: 7.0

IMMERSION IN BIOCIDE: 10/11/ 91
TOTAL TIME IN BIOCIDE: 88 DAYS
REMOVAL FROM BIOCIDE: 1/7/91

TEST DATE: 1/7/ 91
PRESSURE: 800 psi
FLOW RATE: 0.72 gpm
TEMPERATURE: 25 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 7.7

START TIME: 1455
FINISH TIME: 1615
ELAPSED TIME: 1.3 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	2	6.8	1.36 x 18.3 =	24.89 x	1.00	=	24.9	1100	98.1
2	4	6.2	1.24 x 18.3 =	22.69 x	1.00	=	22.7	680	98.8
3	6	6.4	1.28 x 18.3 =	23.42 x	1.00	=	23.4	490	99.1
						AVG.	23.7	757	98.7

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC TEST # 47
ELEMENT # A1318722 (2.5" ELEMENT)
MEMBRANE SHEET # 8722-15B
MEMBRANE I.D. # 8722-47

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/1/91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 32 C
FEED CONDUCTIVITY: 61,000 umhos
FEED pH: 7.5

START TIME: 0820
FINISH TIME: 0920
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY:

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	7.4	1.48 x 18.3 =	27.08 x	0.850 =	23.0	780	98.7
2	3	7.9	1.58 x 18.3 =	28.91 x	0.850 =	24.6	510	99.2
3	5	7.7	1.54 x 18.3 =	28.18 x	0.850 =	23.9	640	98.9
					AVG.	23.8	643	98.9

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SALICYLIC ACID CONC.: 0.2% BUFFER: HCl/NaHCO$_3$ pH: 6.0

IMMERSION IN BIOCIDE: 10/11/91
TOTAL TIME IN BIOCIDE: 89 DAYS
REMOVAL FROM BIOCIDE: 1/8/91

TEST DATE: 1/8/91
PRESSURE: 800 psi
FLOW RATE: 0.72 gpm
TEMPERATURE: 25.0 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.6

START TIME: 1020
FINISH TIME: 1120
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	5.2	1.04 x 18.3 =	19.03 x	1.00 =	19.0	320	99.5
2	4	5.4	1.08 x 18.3 =	19.76 x	1.00 =	19.8	400	99.3
3	6	5.3	1.06 x 18.3 =	19.40 x	1.00 =	19.4	330	99.5
					AVG.	19.4	350	99.4

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC TEST # 41
ELEMENT # A1318722 (2.5" ELEMENT)
MEMBRANE SHEET # 8722-12B
MEMBRANE I.D. # 8722-41

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 9/27/ 91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 33 C
FEED CONDUCTIVITY: 61,000 umhos
FEED pH: 7.1

START TIME: 1340
FINISH TIME: 1440
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	1	7.6	1.52 x 18.3 =	27.82 x	0.840	=	23.4	680	98.9
2	3	7.8	1.56 x 18.3 =	28.55 x	0.840	=	24.0	560	99.1
3	5	7.9	1.58 x 18.3 =	28.91 x	0.840	=	24.3	580	99.0
					AVG.		23.9	607	99.0

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SALICYLIC ACID CONC.: 0.1% BUFFER: HCl/NaHCO3 pH: 5.8

IMMERSION IN BIOCIDE: 10/11/ 91
TOTAL TIME IN BIOCIDE: 91 DAYS
REMOVAL FROM BIOCIDE: 1/10/92

TEST DATE: 1/10/ 92
PRESSURE: 800 psi
FLOW RATE: 0.83 gpm
TEMPERATURE: 25.0 C
FEED CONDUCTIVITY: 57,000 umhos
FEED pH:

START TIME: 1315
FINISH TIME: 1415
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	2	5.9	1.18 x 18.3 =	21.59 x	1.00	=	21.6	590	99.0
2	4	5.8	1.16 x 18.3 =	21.23 x	1.00	=	21.2	400	99.3
3	6	4.8	0.96 x 18.3 =	17.57 x	1.00	=	17.6	350	99.4
					AVG.		20.1	447	99.2

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC **TEST #** 49
ELEMENT # A1318722
MEMBRANE SHEET # 8722-16
MEMBRANE I.D. # 8722-49

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/10/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 29.5 C
FEED CONDUCTIVITY: 61,000 umhos
FEED pH:

START TIME: 0810
FINISH TIME: 0910
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	1	7.4	1.48 x 18.3 =	27.08x	0.841	=	22.8	650	98.9
2	3	7.3	1.46 x 18.3 =	26.72x	0.841	=	22.5	400	99.3
3	5	7.2	1.44 x 18.3 =	26.35x	0.841	=	22.2	780	98.7
					AVG.		22.5	610	99.0

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SALICYLIC ACID **CONC.:** 0.01% **BUFFER:** $HCl/NaHCO_3$ **pH:** 5.7

IMMERSION IN BIOCIDE: 10/11/ 91
TOTAL TIME IN BIOCIDE: 91 DAYS
REMOVAL FROM BIOCIDE: 1/10/92

TEST DATE: 1/10/ 92
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 25.0 C
FEED CONDUCTIVITY: 57,000 umhos
FEED pH: 7.6

START TIME: 1530
FINISH TIME: 1630
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.		GFD	COND. (umhos)	REJECTION (%)
1	2	6.4	1.28 x 18.3 =	23.42x	1.00	=	23.4	940	98.3
2	4	6.0	1.20 x 18.3 =	21.96x	1.00	=	22.0	520	99.1
3	6	5.8	1.16 x 18.3 =	21.23x	1.00	=	21.2	500	99.1
					AVG.		22.2	653	98.8

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC TEST # 56
ELEMENT # A1392165
MEMBRANE SHEET # 2165-2
MEMBRANE I.D. # 2165-56

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/11/91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 32 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.7

START TIME: 1005
FINISH TIME: 1105
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	6.9	1.38 x 18.3 = 25.25 x		0.7165 =	19.3	540	99.1
2	3	7.2	1.44 x 18.3 = 26.35 x		0.7165 =	20.1	380	99.4
3	5	7.4	1.48 x 18.3 = 27.08 x		0.7165 =	20.7	380	99.4
					AVG.	20.0	433	99.3

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BENZALKONIUM
BIOCIDE: CHLORIDE/EDTA CONC.: 0.5% BUFFER: $HCl/NaHCO_3$ pH: 5.8

IMMERSION IN BIOCIDE: 10/11/91
TOTAL TIME IN BIOCIDE: 94 DAYS
REMOVAL FROM BIOCIDE: 1/13/92

TEST DATE: 1/13/92
PRESSURE: 800 psi
FLOW RATE: 0.72 gpm
TEMPERATURE: 24.5 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 7.7

START TIME: 0955
FINISH TIME: 1055
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: — min.
DATA TAKEN BY: KT

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	No Flow	x 18.3 = ___ x		___ =	<0.1	___	___
2	4	"	" x 18.3 = ___ x		___ =	<0.1	___	___
3	6	"	" x 18.3 = ___ x		___ =	<0.1	___	___
					AVG.	—	—	—

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC TEST # 57
ELEMENT # A1392165
MEMBRANE SHEET # 2165-3
MEMBRANE I.D. # 2165-57

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/11/ 91
PRESSURE: 800 psi
FLOW RATE: 0.68 gpm
TEMPERATURE: 32 C
FEED CONDUCTIVITY: 61,000 umhos
FEED pH: 7.6

START TIME: 1135
FINISH TIME: 1235
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	7.7	1.54 x 18.3 =	28.18 x	0.765 =	21.5	680	98.9
2	3	7.8	1.56 x 18.3 =	28.56 x	0.765 =	21.8	450	99.3
3	5	7.5	1.50 x 18.3 =	27.45 x	0.765 =	21.0	540	99.1
					AVG.	21.4	557	99.1

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BENZALKONIUM
BIOCIDE: CHLORIDE/EDTA CONC.: 0.1 BUFFER: $HCl/NaHCO_3$ pH: 5.4

IMMERSION IN BIOCIDE: 10/11/ 91
TOTAL TIME IN BIOCIDE: 94 DAYS
REMOVAL FROM BIOCIDE: 1/13/91

TEST DATE: 1/13/ 91
PRESSURE: 800 psi
FLOW RATE: 0.78 gpm
TEMPERATURE: 26.0 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 7.7

START TIME: 1240
FINISH TIME: 1340
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: — min.
DATA TAKEN BY: C.E.M

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	No Flow	x 18.3 = ___ x	___ =		<0.1	___	___
2	4	"	" x 18.3 = ___ x	___ =		<0.1	___	___
3	6	"	" x 18.3 = ___ x	___ =		<0.1	___	___
					AVG.	—	—	—

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC TEST # 58
ELEMENT # A1392165
MEMBRANE SHEET # 2165-4
MEMBRANE I.D. # 2165-58

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/11/ 91
PRESSURE: 800 psi
FLOW RATE: 0.7 gpm
TEMPERATURE: 32 C
FEED CONDUCTIVITY: 61,000 umhos
FEED pH: 7.5

START TIME: 1245
FINISH TIME: 1400
ELAPSED TIME: 1.25 hr.
COLLECTION TIME: 5.0 min.

DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	7.9	1.58 x 18.3 =	28.91 x	0.765 =	22.1	800	98.7
2	3	7.9	1.58 x 18.3 =	28.91 x	0.765 =	22.1	550	99.1
3	5	7.8	1.56 x 18.3 =	28.56 x	0.765 =	21.8	520	99.1
					AVG.	22	623	99.0

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: BENZALKONIUM CHLORIDE/EDTA CONC.: 0.01% BUFFER: HCl/NaHCO3 pH: 6.5

IMMERSION IN BIOCIDE: 10/11/ 91
TOTAL TIME IN BIOCIDE: 94 DAYS

REMOVAL FROM BIOCIDE: 1/13/92

TEST DATE: 1/13/ 92
PRESSURE: 800 psi
FLOW RATE: 0.72 gpm
TEMPERATURE: 25.0 C
FEED CONDUCTIVITY: 58,000 umhos
FEED pH: 7.7

START TIME: 1525
FINISH TIME: 1625
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 15 min.

DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	3.3	0.22 x 18.3 =	4.0 x	1.00 =	4.0	4000	93.1
2	4	3.6	0.24 x 18.3 =	4.4 x	1.00 =	4.4	3000	94.8
3	6	3.0	0.20 x 18.3 =	3.6 x	1.00 =	4.6	5800	90.0
					AVG.	4.0	4267	92.6

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC **TEST #** 63
ELEMENT # A1392165
MEMBRANE SHEET # 2165-9
MEMBRANE I.D. # 2165-63

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/22/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 31 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.4

START TIME: 1105
FINISH TIME: 1205
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	7.1	1.42 x 18.3 =	25.99 x	0.860 =	22.3	370	99.4
2	3	7.2	1.44 x 18.3 =	26.35 x	0.860 =	22.7	320	99.5
3	5	7.2	1.44 x 18.3 =	26.35 x	0.860 =	22.7	550	99.1
					AVG.	22.6	413	99.3

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SORBIC ACID **CONC.:** 0.1% **BUFFER:** HCl/NaHCO$_3$ **pH:** 5.5

IMMERSION IN BIOCIDE: 10/18/ 91
TOTAL TIME IN BIOCIDE: 88 DAYS
REMOVAL FROM BIOCIDE: 1/14/92

TEST DATE: 1/14/ 92
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 25.0 C
FEED CONDUCTIVITY: 57,000 umhos
FEED pH: 7.7

START TIME: 0925
FINISH TIME: 1025
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	4.7	0.94 x 18.3 =	17.20 x	1.00 =	17.2	260	99.5
2	4	4.5	0.90 x 18.3 =	16.47 x	1.00 =	16.5	160	99.7
3	6	4.6	0.92 x 18.3 =	16.84 x	1.00 =	16.8	240	99.6
					AVG.	16.8	220	99.6

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC **TEST #** 62
ELEMENT # A1392165
MEMBRANE SHEET # 2165-8
MEMBRANE I.D. # 2165-62

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/22/ 91
PRESSURE: 800 psi
FLOW RATE: 0.69 gpm
TEMPERATURE: 30.5 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.4

START TIME: 0950
FINISH TIME: 1050
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	7.7	1.54 x 18.3 =	28.18x	0.865 =	24.4	410	99.3
2	3	7.8	1.56 x 18.3 =	28.55x	0.865 =	24.7	470	99.2
3	5	7.8	1.56 x 18.3 =	28.55x	0.865 =	24.7	450	99.3
					AVG.	24.6	443	99.3

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SORBIC ACID **CONC.:** 0.05% **BUFFER:** $HCl/NaHCO_3$ **pH:** 5.5

IMMERSION IN BIOCIDE: 10/18/ 91
TOTAL TIME IN BIOCIDE: 88 DAYS
REMOVAL FROM BIOCIDE: 1/14/92

TEST DATE: 1/14/ 92
PRESSURE: 800 psi
FLOW RATE: 0.82 gpm
TEMPERATURE: 25.5 C
FEED CONDUCTIVITY: 57,000 umhos
FEED pH: 7.7

START TIME: 1145
FINISH TIME: 1245
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	5.4	1.08 x 18.3 =	19.76x	0.985 =	19.5	300	99.5
2	4	5.2	1.04 x 18.3 =	19.03x	0.985 =	18.7	310	99.4
3	6	5.5	1.10 x 18.3 =	20.13x	0.985 =	19.8	410	99.3
					AVG.	19.3	340	99.4

BIOCIDE STUDY
MEMBRANE TEST DATA

ELEMENT SUPPLIER: FILMTEC **TEST #** 65
ELEMENT # A1392165
MEMBRANE SHEET # 2165-11
MEMBRANE I.D. # 2165-65

CONTROL MEMBRANE TEST DATA BEFORE BIOCIDE EXPOSURE

TEST DATE: 10/22/ 91
PRESSURE: 800 psi
FLOW RATE: 0.70 gpm
TEMPERATURE: 31.5 C
FEED CONDUCTIVITY: 60,000 umhos
FEED pH: 7.4

START TIME: 1355
FINISH TIME: 1455
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5.0 min.
DATA TAKEN BY: K.T.

CELL	SAMPLE	MLS	MLS / MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	1	6.7	1.34 x 18.3 =	24.52 x	0.855 =	21.0	400	99.3
2	3	6.7	1.34 x 18.3 =	24.52 x	0.855 =	21.0	380	99.4
3	5	—	— x 18.3 =	— x	— =	—	—	—
					AVG.	21.0	390	99.3

MEMBRANE TEST DATA AFTER BIOCIDE EXPOSURE

BIOCIDE: SORBIC ACID **CONC.:** 0.01% **BUFFER:** $HCl/NaHCO_3$ **pH:** 5.5

IMMERSION IN BIOCIDE: 10/18/ 91
TOTAL TIME IN BIOCIDE: 88 DAYS
REMOVAL FROM BIOCIDE: 1/14/92

TEST DATE: 1/14/ 92
PRESSURE: 800 psi
FLOW RATE: 0.80 gpm
TEMPERATURE: 25.5 C
FEED CONDUCTIVITY: 57,000 umhos
FEED pH: 7.7

START TIME: 1420
FINISH TIME: 1520
ELAPSED TIME: 1.0 hr.
COLLECTION TIME: 5 min.
DATA TAKEN BY: C.E.M.

CELL	SAMPLE	MLS	MLS/MIN	AREA CORR.	TEMP. CORR.	GFD	COND. (umhos)	REJECTION (%)
1	2	5.3	1.06 x 18.3 =	19.40 x	0.985 =	19.1	580	99.0
2	4	5.3	1.06 x 18.3 =	19.40 x	0.985 =	19.1	580	99.0
3	6	5.9	1.18 x 18.3 =	21.59 x	0.985 =	21.3	370	99.3
					AVG.	19.8	510	99.1

Great Lakes Chemical Corporation

MATERIAL SAFETY DATA SHEET

EMERGENCY TELEPHONE (501) 862-5141

IDENTITY - Bromochlorodimethylhydantoin

SECTION I - PRODUCT INFORMATION

MANUFACTURER'S NAME - GREAT LAKES CHEMICAL CORPORATION

TELEPHONE NUMBER FOR INFORMATION - (317) 497-6100

CAS REGISTRY NO. EPA Registered Pesticide **DATE PREPARED** 7/90

FORMULA $C_5H_6BrClN_2O_2$ **SUPERCEDES** 11/89

CHEMICAL FAMILY - Halogenated hydantoin

PREPARED BY - Research Services Department
Great Lakes Chemical Corporation
West Lafayette, Indiana 47906

SECTION II

HAZARDOUS COMPONENTS (Specify Chemical Identity: Common Names)

COMPONENT	OSHA PEL	ACGIH TLV	Other Limits Recommended
1-Bromo-3-chloro-5,5-dimethylhydantoin	Not estbl.	Not estbl.	Maintain at low levels to avoid dust irritation
Inert ingredients	Not estbl.	Not estbl.	Not estbl.

GLCC Product Code: 899

SECTION III - PHYSICAL/CHEMICAL CHARACTERISTICS

Boiling Point	Not Available
Density (lb/ft^3)	64.5
Vapor Pressure (mm Hg)	Not Available
Melting Point	-320°F
Vapor Density (AIR=1)	Not Available
Evaporation Rate (Butyl Acetate=1)	Not Available
Solubility in Water	Soluble at recommended dosage
Appearance and Odor	White granular solid with faint halogen odor

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SECTION IV - FIRE AND EXPLOSION HAZARD DATA

Flash Point (Method Used)	Not Applicable
Flammable Limits	Not Applicable
LEL	Not Applicable
UEL	Not Applicable

Extinguishing Media — Water

Special Fire Fighting Procedures

In fires fueled by other materials, may release hydrogen bromide or bromine. Wear self-contained breathing apparatus. Ammonium phosphate fire extinguishers should not be used.

Unusual Fire and Explosion Hazards

In large fires fueled by other materials, the product may smolder for prolonged periods emitting a dense black smoke.

SECTION V - REACTIVITY DATA

Stability — Stable X — Unstable

Conditions to Avoid: None

Incompatibility (Materials to Avoid)

Organic chemicals and any other readily oxidizable materials, strong reducing agents.

Hazardous Decomposition or Byproducts

Hydrogen bromide, bromine, hydrogen chloride, chlorine.

Hazardous Polymerization

May Occur Will Not Occur X

Conditions to Avoid: None

SECTION VI - HEALTH HAZARD DATA

Route(s) of Entry:

Inhalation? Yes Skin? No Ingestion? Yes

Health Hazards (Acute and Chronic):

The combined oral LD_{50} in rats is 578 mg/kg. The acute dermal LD_{50} is >2.0 g/kg in rabbits. The primary skin irritation index is 6.1 and the product is considered corrosive to the skin and eyes. Contact with dilute solution (0.1% or less) is non-irritating to the eyes and skin. Acute hazard is the corrosive nature of the solid to skin and eyes, chronic hazards are not known.

Carcinogenicity:

NTP? No IARC Monographs? No OSHA Regulated? No

Signs and Symptoms of Exposure:

The material can cause irreversible eye damage and skin irritation from contact. Inhalation of dust can cause nasal and throat irritation.

Medical Conditions Generally Aggravated by Exposure:

None reported. Existing dermatitis may be aggravated by exposure.

Emergency and First Aid Procedures:

If Swallowed: Seek medical attention promptly. Do not induce vomiting. Do not drink alcohol. Drink at least 8 oz of water (not to exceed 0.23 oz/lb in a child).

If On Skin: Remove contaminated clothing immediately. Brush off excess chemical and wash skin with large volumes of soap and water, flushing the skin with water for at least 15 minutes. If skin irritation develops, seek medical attention.

For Eye Contact: Irrigate eyes with large volumes of room temperature water for at least 15 minutes, then seek medical attention promptly.

NOTE TO PHYSICIAN: Probable mucosal damage may contraindicate the use of gastric lavage.

SECTION VII - PRECAUTIONS FOR SAFE HANDLING AND USE

Steps to be Taken in Case Material is Released or Spilled

Sweep up spilled material and place in a clean, labeled, suitable container. Avoid contact with skin, eyes, or clothing. Avoid inhalation of dusts. Wash area of spill with large amounts of water.

Waste Disposal Method

Wastes resulting from the use of this product may be disposed of on site or at an approved disposal facility. Do not reuse empty container. Triple rinse the container (or equivalent), then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, or incinerate. Burn only if allowed by state and local authorities. If burned, stay out of smoke.

The NFPA has judged the product to be a class 2 oxidizer in accordance with NFPA 43A-1980.

Precautions to be Taken in Handling and Storing

Keep product dry in tightly closed container when not in use. Store in a cool, dry, well ventilated area away from heat, open flames, organic chemicals and sunlight. Transfer contents only to clean and dry containers. Always replace cover.

Other Precautions

Do not contaminate water, food, or feed by storage or disposal. Open dumping is prohibited.

DOT: Oxidizer, n.o.s. (1-Bromo-3-chloro-5,5-dimethylhydantoin) UN 1479.

SECTION VIII - CONTROL MEASURES

Respiratory Protection

NIOSH approved dust mask is essential where dusting may occur.

Ventilation

Local Exhaust - Use to minimize dusting

Special - None

Mechanical - Use for general area control

Other - None

Protective Gloves - Essential to wear rubber or plastic gloves

Eye Protection - Chemical safety goggles

Other Protective Equipment - Clothing designed to minimize skin contact

Work Hygienic Practices - Wash thoroughly after handling

Information on this form is furnished solely for the purpose of compliance with OSHA's Hazard Communication Standard, 29CFR 1910.1200 and shall not be used for any other purpose.

DLMcF:sb:082

Great Lakes Chemical Corporation

MATERIAL SAFETY DATA SHEET

EMERGENCY TELEPHONE (501) 862-5141

IDENTITY - CN-1754 ; Bronopol; bromonitropropane diol

SECTION I - PRODUCT INFORMATION

MANUFACTURER'S NAME - GREAT LAKES CHEMICAL CORPORATION

TELEPHONE NUMBER FOR INFORMATION - (317) 497-6100

CAS REGISTRY NO. 52-51-7 **DATE PREPARED** 6/90

FORMULA $C_3H_6BrNO_4$ **SUPERCEDES** 1/90

CHEMICAL FAMILY - Halogenated substituted alkanol

PREPARED BY - Research Services Department
Great Lakes Chemical Corporation
West Lafayette, Indiana 47906

SECTION II

HAZARDOUS COMPONENTS (Specify Chemical Identity: Common Names)

COMPONENT	OSHA PEL	ACGIH TLV	Other Limits Recommended
CN-1754	Not establ.	Not establ.	Maintain at low levels to avoid dust irritation

GLCC Product Code: 899

SECTION III - PHYSICAL/CHEMICAL CHARACTERISTICS

Boiling Point	Not Available
Specific Gravity (water=1)	Not Available
Vapor Pressure (mm Hg)	Not Available
Melting Point	130-133°C
Vapor Density (AIR=1)	Not Available
Evaporation Rate (Butyl Acetate=1)	Not Available
Solubility in Water	Not Available
Appearance and Odor	White crystals, odor not available

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

Flash Point (Method Used)	Not Applicable
Flammable Limits	Not Applicable
LEL	Not Applicable
UEL	Not Applicable

Extinguishing Media

All conventional media are suitable

Special Fire Fighting Procedures

Wear self-contained breathing apparatus

Unusual Fire and Explosion Hazards

Toxic and corrosive hydrogen bromide and nitrogen compounds can be released in fire situations.

SECTION V - REACTIVITY DATA

Stability Stable X Unstable

Conditions to Avoid: None known

Incompatibility (Materials to Avoid)

Alkalis, oxidizers, reducing agents, acid chlorides, acid anhydrides.

Hazardous Decomposition or Byproducts

Hydrogen bromide, nitrogen oxides, carbon monoxide.

Hazardous Polymerization

May Occur Will Not Occur X

Conditions to Avoid: None

SECTION VI - HEALTH HAZARD DATA

Route(s) of Entry:

Inhalation? Yes Skin? Yes Ingestion? Yes

Health Hazards (Acute and Chronic):

The acute oral LD_{50} with rats is 229 mg/kg. The dermal LD_{50} with rats is greater than 2000 mg/kg. The dermal primary irritation index with rabbits is 4.6. The material is considered moderately irritating to the skin. The maximum average score was 110 at 21 days in the eye irritation study with rabbits. The material is a severe eye irritant and corrosive to the eyes. Chronic health hazards are not known.

Carcinogenicity:

NTP? No IARC Monographs? No OSHA Regulated? No

Signs and Symptoms of Exposure:

Contact may cause irritation.

Medical Conditions Generally Aggravated by Exposure:

Not available.

Emergency and First Aid Procedures:

Eyes: Flush with water for 15 minutes. Get medical attention.

Skin: Flush with water. If irritation occurs, get medical attention.

Inhalation: Remove person to fresh air, get medical attention.

Ingestion: Get medical attention.

SECTION VII - PRECAUTIONS FOR SAFE HANDLING AND USE

Steps to be Taken in Case Material is Released or Spilled

Wear protective equipment. Avoid breathing dust. Collect spill and place in suitable labeled container.

Waste Disposal Method

Dispose of waste in an approved chemical incinerator or chemical landfill as allowed by current laws and regulations.

Precautions to be Taken in Handling and Storing

Avoid contact and dust inhalation.

Other Precautions

Keep container closed.

SECTION VIII - CONTROL MEASURES

Respiratory Protection

Wear NIOSH approved dust respirator if dusting occurs.

Ventilation

Local Exhaust - Use to minimize dusting

Special - None

Mechanical - Use for general area control

Other - None

Protective Gloves - Rubber or plastic

Eye Protection - Safety glasses or goggles

Other Protective Equipment - Body-covering clothing

Work Hygienic Practices - Wash thoroughly after handling

Information on this form is furnished solely for the purpose of compliance with OSHA's Hazard Communication Standard, 29CFR 1910.1200 and shall not be used for any other purpose.

DLMcF:sb:008

DATE: 09/21/91 ACCT: [redacted]
INDEX: 28912620184 CAT NO: G1511 PO NBR: [redacted]

GLUTARALDEHYDE, 25-50% IN AQUEOUS SOLUTION
GLUTARALDEHYDE, 25-50% IN AQUEOUS SOLUTION
GLUTARALDEHYDE, 25-50% IN AQUEOUS SOLUTION

MATERIAL SAFETY DATA SHEET

FISHER SCIENTIFIC
CHEMICAL DIVISION
1 REAGENT LANE
FAIR LAWN NJ 07410
(201) 796-7100

EMERGENCY NUMBER: (201) 796-7100
CHEMTREC ASSISTANCE: (800) 424-9300

SUBSTANCE IDENTIFICATION

CAS-NUMBER 111-30-8

SUBSTANCE: **GLUTARALDEHYDE, 25-50% IN AQUEOUS SOLUTION**

TRADE NAMES/SYNONYMS:
CIDEX; 1,5-PENTANEDIONE; 1,5-PENTANEDIAL; GLUTARAL; POTENTIATED ACID GLUTARALDEHYDE; SONACIDE; GLUTARIC DIALDEHYDE; 0-2957; G-151; ACC10421

CHEMICAL FAMILY:
ALDEHYDE, ALIPHATIC

MOLECULAR FORMULA: C5-H8-O2

MOLECULAR WEIGHT: 100.1

CERCLA RATINGS (SCALE 0-3): HEALTH=3 FIRE=0 REACTIVITY=0 PERSISTENCE=0
NFPA RATINGS (SCALE 0-4): HEALTH=3 FIRE=0 REACTIVITY=0

COMPONENTS AND CONTAMINANTS

COMPONENT: GLUTARALDEHYDE PERCENT: 25.0-50.0
CAS# 111-30-8

COMPONENT: WATER PERCENT: 75.0-50.0

OTHER CONTAMINANTS: NONE

EXPOSURE LIMITS:
GLUTARALDEHYDE:
0.2 PPM (0.8 MG/M3) OSHA CEILING
0.2 PPM (0.8 MG/M3) ACGIH CEILING
0.2 PPM (0.8 MG/M3) NIOSH RECOMMENDED CEILING
0.2 PPM (0.8 MG/M3) DFG MAK TWA (SENSITIZATION);
0.4 PPM (1.6 MG/M3) DFG MAK 5 MINUTE PEAK, MOMENTARY VALUE, 8 TIMES/SHIFT

PHYSICAL DATA

DESCRIPTION: COLORLESS TO PALE YELLOW LIQUID.

BOILING POINT: 369 F (187 C) DECOMPOSES MELTING POINT: 7 F (-14 C)

SPECIFIC GRAVITY: 0.7 VAPOR PRESSURE: 17 MMHG @ 20 C

SOLUBILITY IN WATER: SOLUBLE VAPOR DENSITY: 1.065

SOLVENT SOLUBILITY: ALCOHOL, BENZENE, DMSO, ETHER, ACETONE

FIRE AND EXPLOSION DATA

FIRE AND EXPLOSION HAZARD:
NEGLIGIBLE FIRE HAZARD WHEN EXPOSED TO HEAT OR FLAME.

FIREFIGHTING MEDIA:
DRY CHEMICAL, CARBON DIOXIDE, WATER SPRAY OR REGULAR FOAM (1990 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.5).

FOR LARGER FIRES, USE WATER SPRAY, FOG OR REGULAR FOAM (1990 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.5).

FIREFIGHTING:
MOVE CONTAINER FROM FIRE AREA IF YOU CAN DO IT WITHOUT RISK. DO NOT SCATTER SPILLED MATERIAL WITH HIGH-PRESSURE WATER STREAMS. DIKE FIRE-CONTROL WATER FOR LATER DISPOSAL (1990 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.5, GUIDE

PAGE 31).

USE AGENTS SUITABLE FOR TYPE OF SURROUNDING FIRE. AVOID BREATHING HAZARDOUS VAPORS, KEEP UPWIND.

TOXICITY

GLUTARALDEHYDE:
IRRITATION DATA: 6 MG/3 DAYS INTERMITTENT SKIN-HUMAN SEVERE; 13 MG OPEN SKIN-RABBIT MILD; 2 MG/24 HOURS SKIN-RABBIT SEVERE; 1 MG EYE-RABBIT SEVERE; 250 UG/24 HOURS EYE-RABBIT SEVERE.
TOXICITY DATA: 2560 MG/KG SKIN-RABBIT LD50; 134 MG/KG ORAL-RAT LD50; 100 MG/KG ORAL-MOUSE LD50; 50 MG/KG ORAL-GUINEA PIG LD50; 2390 MG/KG SUBCUTANEOUS-RAT LD50; 1430 MG/KG SUBCUTANEOUS-MOUSE LD50; 15300 UG/KG INTRAVENOUS-RAT LD50; 15400 UG/KG INTRAVENOUS-MOUSE LD50; 17900 UG/KG INTRAPERITONEAL-RAT LD50; 13900 UG/KG INTRAPERITONEAL-MOUSE LD50; MUTAGENIC DATA (RTECS); REPRODUCTIVE EFFECTS DATA (RTECS).
CARCINOGEN STATUS: NONE.
LOCAL EFFECTS: CORROSIVE- EYES; IRRITANT- INHALATION, SKIN.
ACUTE TOXICITY LEVEL: TOXIC BY INGESTION; SLIGHTLY TOXIC BY DERMAL ABSORPTION.
TARGET EFFECTS: SENSITIZER- SKIN. CENTRAL NERVOUS SYSTEM DEPRESSANT.

HEALTH EFFECTS AND FIRST AID

INHALATION:
GLUTARALDEHYDE:
IRRITANT/NARCOTIC.
ACUTE EXPOSURE- INHALATION MAY CAUSE NOSE AND UPPER RESPIRATORY TRACT IRRITATION. SEVERE EXPOSURE MAY CAUSE COUGHING, SHORTNESS OF BREATH AND CENTRAL NERVOUS SYSTEM DEPRESSION WITH HEADACHE, DIZZINESS AND DROWSINESS.
CHRONIC EXPOSURE- PROLONGED OR REPEATED EXPOSURE MAY CAUSE MUCOUS MEMBRANE IRRITATION.

FIRST AID- REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, PERFORM ARTIFICIAL RESPIRATION. KEEP PERSON WARM AND AT REST. TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY.

SKIN CONTACT:
GLUTARALDEHYDE:
IRRITANT/SENSITIZER/NARCOTIC.
ACUTE EXPOSURE- CONTACT WITH THE SKIN MAY CAUSE IRRITATION. SENSITIZATION DERMATITIS MAY *OCCUR IN PREVIOUSLY EXPOSED PERSONS*. SUBSTANCE MAY BE ABSORBED THROUGH INTACT SKIN AND AFFECT THE CENTRAL NERVOUS SYSTEM WITH HEADACHE, DIZZINESS AND DULLNESS.
CHRONIC EXPOSURE- INTERMITTENT HUMAN EXPOSURE TO A SMALL AMOUNT FOR 3 DAYS PRODUCED SEVERE IRRITATION. REPEATED OR PROLONGED EXPOSURE MAY CAUSE SENSITIZATION DERMATITIS.

FIRST AID- REMOVE CONTAMINATED CLOTHING AND SHOES IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

EYE CONTACT:
GLUTARALDEHYDE:
CORROSIVE.
ACUTE EXPOSURE- CONTACT WITH THE EYES MAY CAUSE SEVERE IRRITATION, REDNESS, PAIN, AND POSSIBLY CORNEAL BURNS. HOWEVER, A 40% SOLUTION APPLIED TO RABBIT EYES AND RINSED 2 MINUTES LATER PRODUCED NO INJURY.
CHRONIC EXPOSURE- PROLONGED OR REPEATED EXPOSURE MAY CAUSE CONJUNCTIVITIS.

FIRST AID- WASH EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (AT LEAST 15-20 MINUTES). CONTINUE IRRIGATING WITH NORMAL SALINE UNTIL THE PH HAS RETURNED TO NORMAL (30-60 MINUTES). COVER WITH STERILE BANDAGES. GET MEDICAL ATTENTION IMMEDIATELY.

INGESTION:
GLUTARALDEHYDE:
NARCOTIC/TOXIC.
ACUTE EXPOSURE- INGESTION MAY CAUSE MOUTH AND STOMACH IRRITATION, ABDOMINAL

[illegible] MAY AFFECT THE [illegible]
LETHAL TO RATS AND MICE TESTED. NO SYMPTOMS WERE REPORTED.
CHRONIC EXPOSURE- MALE AND FEMALE RATS CHRONICALLY FED BEFORE MATING EXHIBITED EFFECTS ON THE REPRODUCTIVE ORGANS. PREGNANT RATS EXHIBITED FETOTOXICITY AND DEVELOPMENTAL ABNORMALITIES OF THE CRANIOFACIAL, MUSCULOSKELETAL, AND CENTRAL NERVOUS SYSTEMS OF THE FETUSES.

FIRST AID- IF THE PERSON IS CONSCIOUS AND NOT CONVULSING, INDUCE EMESIS BY GIVING SYRUP OF IPECAC FOLLOWED BY WATER. (IF VOMITING OCCURS KEEP THE HEAD BELOW THE HIPS TO PREVENT ASPIRATION). REPEAT IN 20 MINUTES IF NOT EFFECTIVE INITIALLY. GIVE ACTIVATED CHARCOAL. IN PATIENTS WITH DEPRESSED RESPIRATION OR IF EMESIS IS NOT PRODUCED, PERFORM GASTRIC LAVAGE CAUTIOUSLY (DREISBACH, HANDBOOK OF POISONING, 12TH ED.). TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GASTRIC LAVAGE SHOULD BE PERFORMED BY QUALIFIED MEDICAL PERSONNEL. GET MEDICAL ATTENTION IMMEDIATELY.

DATE: 09/21/91 ACCT: [redacted]
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ANTIDOTE:
NO SPECIFIC ANTIDOTE. TREAT SYMPTOMATICALLY AND SUPPORTIVELY.

REACTIVITY

REACTIVITY:
STABLE UNDER NORMAL TEMPERATURES AND PRESSURES.

INCOMPATIBILITIES:
GLUTARALDEHYDE:
OXIDIZERS: VIOLENT REACTION.
REDUCING AGENTS: INCOMPATIBLE.
ACIDS: INCOMPATIBLE.
ALKALIES: INCOMPATIBLE.

DECOMPOSITION:
THERMAL DECOMPOSITION MAY RELEASE TOXIC AND/OR HAZARDOUS GASES.

POLYMERIZATION:
MAY UNDERGO SLOW, NON-HAZARDOUS POLYMERIZATION ON PROLONGED STORAGE AT AMBIENT TEMPERATURES.

****

CONDITIONS TO AVOID

AVOID CONTACT WITH HEAT, SPARKS, FLAMES, OR OTHER SOURCES OF IGNITION. VAPORS MAY BE EXPLOSIVE. AVOID OVERHEATING OF CONTAINERS; CONTAINERS MAY VIOLENTLY RUPTURE IN HEAT OF FIRE. AVOID CONTAMINATION OF WATER SOURCES.

AVOID REMOVAL OF WATER.
AVOID CONTAMINATION BY ACIDS AND ALKALIES.

****

SPILL AND LEAK PROCEDURES

OCCUPATIONAL SPILL:
SHUT OFF IGNITION SOURCES. STOP LEAK IF YOU CAN DO IT WITHOUT RISK. USE WATER SPRAY TO REDUCE VAPORS. FOR SMALL SPILLS, TAKE UP WITH SAND OR OTHER ABSORBENT MATERIAL AND PLACE INTO CONTAINERS FOR LATER DISPOSAL. FOR LARGER SPILLS, DIKE FAR AHEAD OF SPILL FOR LATER DISPOSAL. NO SMOKING, FLAMES OR FLARES IN HAZARD AREA. KEEP UNNECESSARY PEOPLE AWAY; ISOLATE HAZARD AREA AND RESTRICT ENTRY.

PROTECTIVE EQUIPMENT

VENTILATION:
PROVIDE LOCAL EXHAUST OR PROCESS ENCLOSURE VENTILATION TO MEET PUBLISHED EXPOSURE LIMITS.

RESPIRATOR:
THE FOLLOWING RESPIRATORS ARE RECOMMENDED BASED ON INFORMATION FOUND IN THE PHYSICAL DATA, TOXICITY AND HEALTH EFFECTS SECTIONS. THEY ARE RANKED IN ORDER FROM MINIMUM TO MAXIMUM RESPIRATORY PROTECTION.
THE SPECIFIC RESPIRATOR SELECTED MUST BE BASED ON CONTAMINATION LEVELS FOUND IN THE WORK PLACE, MUST BE BASED ON THE SPECIFIC OPERATION, MUST NOT EXCEED THE WORKING LIMITS OF THE RESPIRATOR AND MUST BE JOINTLY APPROVED BY THE NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH AND THE MINE SAFETY AND HEALTH ADMINISTRATION (NIOSH-MSHA).

ANY TYPE 'C' SUPPLIED-AIR RESPIRATOR WITH A FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE OR WITH A FULL FACEPIECE, HELMET OR HOOD OPERATED IN CONTINOUS-FLOW MODE.

ANY SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE.

FOR FIREFIGHTING AND OTHER IMMEDIATELY DANGEROUS TO LIFE OR HEALTH CONDITIONS:

ANY SELF-CONTAINED BREATHING APPARATUS THAT HAS A FULL FACEPIECE AND IS OPERATED IN A PRESSURE-DEMAND OR OTHER POSITIVE-PRESSURE MODE.

ANY SUPPLIED-AIR RESPIRATOR THAT HAS A FULL FACEPIECE AND IS OPERATED IN A PRESSURE-DEMAND OR OTHER POSITIVE-PRESSURE MODE IN COMBINATION WITH AN AUXILIARY SELF-CONTAINED BREATHING APPARATUS OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE-PRESSURE MODE.

CLOTHING:
EMPLOYEE MUST WEAR APPROPRIATE PROTECTIVE (IMPERVIOUS) CLOTHING AND EQUIPMENT TO PREVENT ANY POSSIBILITY OF SKIN CONTACT WITH THIS SUBSTANCE.

GLOVES:
EMPLOYEE MUST WEAR APPROPRIATE PROTECTIVE GLOVES TO PREVENT CONTACT WITH THIS SUBSTANCE.

EYE PROTECTION:

EMPLOYEE MUST WEAR SPLASH-PROOF OR DUST-RESISTANT SAFETY GOGGLES AND A FACESHIELD TO PREVENT CONTACT WITH THIS SUBSTANCE.

EMERGENCY WASH FACILITIES:
WHERE THERE IS ANY POSSIBILITY THAT AN EMPLOYEE'S EYES AND/OR SKIN MAY BE EXPOSED TO THIS SUBSTANCE, THE EMPLOYER SHOULD PROVIDE AN EYE WASH FOUNTAIN AND QUICK DRENCH SHOWER WITHIN THE IMMEDIATE WORK AREA FOR EMERGENCY USE.

AUTHORIZED - FISHER SCIENTIFIC, INC.
CREATION DATE: 07/08/85 REVISION DATE: 04/08/91

-ADDITIONAL INFORMATION-
THIS INFORMATION IS BELIEVED TO BE ACCURATE AND REPRESENTS THE BEST INFORMATION CURRENTLY AVAILABLE TO US. HOWEVER, WE MAKE NO WARRANTY OF MERCHANTABILITY OR ANY OTHER WARRANTY, EXPRESS OR IMPLIED, WITH RESPECT TO SUCH INFORMATION, AND WE ASSUME NO LIABILITY RESULTING FROM ITS USE. USERS SHOULD MAKE THEIR OWN INVESTIGATIONS TO DETERMINE THE SUITABILITY OF THE INFORMATION FOR THEIR PARTICULAR PURPOSES.

MATERIAL SAFETY DATA SHEET

NALCO "Kathon"

PRODUCT NALCO 2593 MICROBIOCIDE

Emergency Telephone Number
Medical (708) 920-1510 (24 hours)

ES
MJ

SECTION 1 PRODUCT IDENTIFICATION

TRADE NAME: NALCO 2593 MICROBIOCIDE
DESCRIPTION: An aqueous solution of substituted isothiazolinone

NFPA 704M/HMIS RATING: 3/3 HEALTH 0/0 FLAMMABILITY 0/0 REACTIVITY 0 OTHER
0=Insignificant 1=Slight 2=Moderate 3=High 4=Extreme

SECTION 2 HAZARDOUS INGREDIENTS

Our hazard evaluation has identified the following chemical ingredient(s) as hazardous under OSHA's Hazard Communication Rule, 29 CFR 1910.1200. Consult Section 14 for the nature of the hazard(s).

INGREDIENT(S)	CAS #	APPROX.%
5-chloro-2-methyl-4 isothiazolin-3-one	26172-55-4	1.15
2-methyl-4-isothiazolin-3-one	2682-20-4	0.35

SECTION 3 PRECAUTIONARY LABEL INFORMATION

DANGER: Corrosive. Causes eye damage and skin burns. May cause allergic skin reaction. May be harmful if inhaled. May be fatal if swallowed or absorbed through the skin. Do not get in eyes, on skin, or on clothing. Wear goggles or face shield and rubber gloves when handling. Avoid breathing vapor or mist. Avoid contamination of food. Do not take internally. Wash thoroughly after handling.

SECTION 4 FIRST AID INFORMATION

EYES: Immediately flush for at least 15 minutes while holding eyelids open. Call a physician at once.

SKIN: Wash thorougly with soap and rinse with water. Remove and wash contaminated clothing before reuse.

INGESTION: Do not induce vomiting. Drink promptly a large quantity of milk, egg whites, gelatin solution, or, if these are not available, drink large quantities of water. Avoid alcohol. Call a physician immediately.

INHALATION: Remove immediately to fresh air. If not breathing, apply artificial respiration. If breathing is difficult, give oxygen. Call a physician.

NOTE TO PHYSICIAN: No specific antidote is known. Based on the individual reactions of the patient, the physician's judgment should be used to control symptoms and clinical condition.

SECTION 6 TOXICOLOGY INFORMATION (CONTINUED)

COMMENTS: Four-hour nominal concentration for a solution containing 1% active ingredients.

SKIN IRRITATION INDEX DRAIZE RATING: Severe irritant

EYE IRRITATION INDEX DRAIZE RATING: Corrosive (corneal damage)

SKIN SENSITIZATION: This product is a human sensitizer in its undiluted form.

A Guinea pig (Buehler Technique) sensitization study with an induction dosage of 90 ppm of active ingredients followed by a insult of 429 ppm of active ingredients was positive.

A human repeated insult patch study of 28 ppm active ingredients followed by a insult of 56 ppm of active ingredients resulted in no effect to the subjects tested.

SUBCHRONIC TOXICITY RESULTS: A 90-day dietary study in dogs of 840 ppm of the product's active ingredients resulted in no mortalities or pathological findings. A 90-day dermal study in rabbits of 0.4 mg/kg/day of the product's active ingredients resulted in no irritation or pathological effects.

CHRONIC TOXICITY RESULTS: A teratology study with rabbits and rats was negative with dosages of active ingredient ranging from 1.5 mg/kg to 15 mg/kg. Mutagenicity results were equivocal. A 30-month skin painting mouse study with applications of 400 ppm of active ingredients three times per week showed no increase tumor frequency over control animals.

SECTION 7 PHYSICAL AND CHEMICAL PROPERTIES

COLOR: Pale yellow to green	FORM: Liquid	ODOR: Mild
DENSITY:	8.6 lbs/gal.	
SOLUBILITY IN WATER:	Completely	
pH (NEAT) =	3 - 5	ASTM E-70
FREEZE POINT:	25 Degrees F	ASTM D-1177
FLASH POINT:	None	

NOTE: These physical properties are typical values for this product.

SECTION 8 FIRE AND EXPLOSION INFORMATION

FLASH POINT: None

SECTION 11 SPILL AND DISPOSAL INFORMATION (CONTINUED)

SPILL CONTROL AND RECOVERY:

Small liquid spills: Contain with absorbent material, such as clay, soil or any commercially available absorbent. Shovel reclaimed liquid and absorbent into recovery or salvage drums for disposal. Refer to CERCLA in Section 14.

Large liquid spills: Dike to prevent further movement and reclaim into recovery or salvage drums or tank truck for disposal. Refer to CERCLA in Section 14.

This product is toxic to fish. It should not be directly discharged into lakes, ponds, streams, waterways or public water supplies.

DISPOSAL: If this product becomes a waste, it meets the criteria of a hazardous waste as defined under the Resources Conservation and Recovery Act (RCRA) 40 CFR 261. Hazardous Waste D002.

As a hazardous liquid waste, it must be solidified with stabilizing agents (such as sand, fly ash, or cement) so that no free liquid remains before disposal to a licensed industrial waste landfill (Hazardous Waste Treatment, Storage and Disposal facility). A hazardous liquid waste can also be incinerated in accordance with local, state, and federal regulations.

Pesticide wastes are toxic. Improper disposal of excess pesticide, spray mixture, or rinsate is a violation of Federal Law. If these wastes cannot be disposed of by use according to label instruction, contact your State Pesticide or Environmental Control Agency, or the Hazardous Waste representative at the nearest EPA Regional Office for guidance.

METAL CONTAINERS: Triple rinse (or equivalent). Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, or by other procedures approved by state and local authorities.

PLASTIC CONTAINERS: Do not reuse empty container. Triple rinse (or equivalent). Then puncture and dispose of in a sanitary landfill, or, if allowed by state and local authorities, by burning. If burned, stay out of smoke.

SECTION 12 ENVIRONMENTAL INFORMATION

CHEMICAL OXYGEN DEMAND (COD): 20,000 mg/L

TOTAL ORGANIC CARBON (TOC): 7,850 mg/L

SECTION 13 TRANSPORTATION INFORMATION

DOT PROPER SHIPPING NAME/HAZARD CODE - CORROSIVE LIQUID, N.O.S.
CORROSIVE MATERIAL UN 1760
CONTAINS - 5-CHLORO-2-METHYL-4-ISOTHIAZOLIN-3-ONE, CUPRIC NITRATE

SECTION 14 REGULATORY INFORMATION

The following regulations apply to this product.

FEDERAL REGULATIONS:

OSHA'S HAZARD COMMUNICATION RULE, 29 CFR 1910.1200:
Based on our hazard evaluation, the following ingredients in this product are hazardous and the reasons are shown below.

5-chloro-2-methyl-4 isothiazolin-3-one - Corrosive, sensitizer
2-methyl-4-isothiazolin-3-one - Corrosive, sensitizer

5-chloro-2-methyl-4 isothiazolin-3-one (mist or aerosol) = 0.5 mg/m³ TLV
Manufacturer's recommendation

CERCLA, 40 CFR 117, 302:
This product contains cupric nitrate, a Reportable Quantity (RQ) substance and if 52,000 pounds of product are released, it requires notification to the NATIONAL RESPONSE CENTER, WASHINGTON, D. C. 1-800-424-8802).

SARA/SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT OF 1986
(TITLE III) - SECTIONS 302, 311, 312 AND 313:

SECTION 302 - EXTREMELY HAZARDOUS SUBSTANCES 40 CFR 355):
This product does not contain ingredients listed in Appendix A and B as an Extremely Hazardous Substance.

SECTIONS 311 and 312 - MATERIAL SAFETY DATA SHEET REQUIREMENTS (40 CFR 370):
Our hazard evaluation has found this product to be hazardous. The product should be reported under the following EPA hazard categories:

XX Immediate (acute) health hazard
-- Delayed (chronic) health hazard
-- Fire hazard
-- Sudden release of pressure hazard
-- Reactive hazard

SECTION 313 - LIST OF TOXIC CHEMICALS (40 CFR 372):

SECTION 14 REGULATORY INFORMATION (CONTINUED)

INTERNATIONAL REGULATIONS: *

*

This is not a WHMIS controlled product under The House of Commons of Canada Bill C-70. *

SECTION 15 ADDITIONAL INFORMATION

Note: Other toxicological results are available upon request.

SECTION 16 USER'S RESPONSIBILITY

This product material safety data sheet provides health and safety information. The product is to be used in applications consistent with our product literature. Individuals handling this product should be informed of the recommended safety precautions and should have access to this information. For any other uses, exposures should be evaluated so that appropriate handling practices and training programs can be established to ensure safe workplace operations. Please consult your local sales representative for any further information.

SECTION 17 BIBLIOGRAPHY

ANNUAL REPORT ON CARCINOGENS, U.S. Department of Health and Human Services, Public Health Service, PB 33-135855, 1983.

CASARETT AND DOULL'S TOXICOLOGY, THE BASIC SCIENCE OF POISONS, Doull, J., Klaassen, C. D., and Admur, M. O., eds., Macmillian Publishing Company, Inc., N. Y., 2nd edition, 1980.

CHEMICAL HAZARDS OF THE WORKPLACE, Proctor, N. H., and Hughes, J. P., eds., J. P. Lipincott Company, N.Y., 1981.

DANGEROUS PROPERTIES OF INDUSTRIAL MATERIALS, Sax, N. Irving, ed., Van Nostrand Reinhold Company, N.Y., 6th edition, 1984.

IARC MONOGRAPHS ON THE EVALUATION OF THE CARCINOGENIC RISK OF CHEMICALS TO MAN, Geneva: World Health Organization, International Agency for Research on Cancer, 1972-1977.

PATTY'S INDUSTRIAL HYGIENE AND TOXICOLOGY, Clayton, G. D., Clayton, F. E., eds., John Wiley and Sons, N. Y., 3rd edition, Vol. 2 A-C, 1981.

REGISTRY OF TOXIC EFFECTS ON CHEMICAL SUBSTANCES, U.S. Department of Health and Human Services, Public Health Service, Center for Disease

NALCO

Material Safety Data Sheet Description and Explanation of Terms

Emergency Telephone Number

Medical (708) 920-1510 (24 hours)

General

The Material Safety Data Sheet (MSDS) has, over the years, become the major media for transmitting health and safety information on chemical products. It is therefore natural that it has been included in the new OSHA Hazard Communication Standard (29CFR 1910.1200) as the key document along with the container label to provide hazard information to employees and employers.

These new OSHA regulations require chemical manufacturers to evaluate each chemical produced to determine if it is hazardous. The definition of "hazardous" has been expanded from the usual "flammable, corrosive, oxidizer, explosive, toxic or highly toxic agents, carcinogen, etc." to include combustibles as well as irritants. Consequently, many products that had not previously been classified as "hazardous" now fall into this classification under OSHA.

The new regulations require chemical manufacturers and importers to prepare and distribute an MSDS for all hazardous chemicals and that each container of hazardous chemical leaving the workplace be labeled. In addition, the chemical manufacturer is to provide a copy of the MSDS to the purchaser at the time of shipment or before.

Nalco has established a computerized program to send MSDS's to each purchaser upon receipt of a first order after November 25, 1985. The MSDS will automatically be sent to the attention of the purchasing agent at the "ship to address." A revised MSDS will also be sent to that same address when a change has been made to the MSDS.

MSDS's will also continue to be available through your Nalco Sales Representative or upon request to Nalco.

The Nalco MSDS complies with all of the requirements of the OSHA regulation. In addition, it provides you with all of the important information regarding the safe handling of our products, recommended protection measures, toxicological data, and the status of our products under various federal and state environmental and safety regulations. In short, we have put all of this information into one document for your convenience and easy use.

Nalco, as part of our overall commitment to product safety, is providing MSDS's on all of our chemical products regardless of whether the product is hazardous or not. The OSHA regulations require an MSDS to be prepared only for certain hazardous chemicals.

This MSDS section description and explanation of terms is designed to assist your interpretation of the MSDS so that you may receive full value from the document.

Section 1 — Product Identification

This section identifies the Nalco product by Trade Name or Product Number. This is the same trade name or product number that will appear on the product container allowing you to match up the product label with the MSDS.

Nalco also provides a generic chemical description of all major ingredients, both hazardous and non-hazardous. This is designed to give your health and safety personnel information on the class of chemistry(s) in our product without compromising the proprietary nature of the formulation.

The third part of this section is the National Fire Protection Association (NFPA) 704M rating designation. This popular rating system is used to give you a quick summary of the hazards of the product regarding health, flammability, reactivity and other hazards. Based on NFPA definition, an organic product will always have a flammability rating of at least (1) with inorganics having a rating of (0).

Section 2 — Hazardous Ingredients

We have evaluated our formulations for hazardous properties and identify those chemical ingredients which we believe cause or contribute to the hazard. As required by OSHA, these substances are identified if they are present in quantities greater than 1%, or in the case of carcinogens, greater than 0.1%, or if our hazard evaluation determines a hazard exists at lower concentrations. The hazardous ingredients are identified by specific chemical name and their CAS number (the Chemical Abstract Service number for that specific chemical).

To assist your industrial hygiene and safety personnel, Nalco identifies general or relative concentration ranges into which the exact percentage of the hazardous ingredient falls. This should enable your safety professional to evaluate the need for air sampling, employee monitoring, or other protective measures. Since most of our product formulations are proprietary, exact percentages will be given only when there are no trade secret concerns.

In a few cases where disclosure of specific chemical name and CAS number of a hazardous ingredient would release trade secrets, we have identified the chemical as "proprietary" as permitted by the OSHA regulation. In the event of an injury or accident, procedures are established to communicate the specific identity to health professionals who may have need for this information. In all

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cases, the hazard information and safe handling recommendations are provided.

Section 3 — Precautionary Label Information

The drum or product container is labeled showing product identity, health and safety precautions as well as other information on handling and use of the product. That portion of the label which covers health and safety precautions is included in this section of the MSDS. In this way, you can easily refer to what is shown on the drum label without actually seeing the container.

Empty drums or containers may contain residual product and should be treated in accordance with the label requirement unless the empty container has been properly reconditioned. By EPA Standards (RCRA – 40CFR 261.7), a container is considered to be "empty" when it contains: 1) no more than 1 inch (2.5 centimeters) of product, or 2) no more than 3% by weight of the total capacity of the container if the container is less than or equal to 110 gallons in size or 3) no more than 0.3% by weight if the container is greater than 110 gallons in size. Empty drums that formerly contained chemicals listed in 40CFR 261.33 (c) must be triple rinsed using a solvent capable of removing the commerical chemical to qualify as "empty." Quantities of chemical greater than those indicated above which remain in the container are considered "wastes" when disposing of the container and appropriate RCRA regulations will apply.

Section 4 — First Aid Information

This section is designed to provide first aid information for the typical routes of exposure. The recommendations should be followed in all cases. If exposure causes unexpected or delayed effects, or severe reaction or injury, you should immediately consult a physician. Nalco ALERT, our medical emergency system (312/920-1510) should be called by the attending physician or others. Nalco ALERT operates 24 hours/day, seven days/week and is staffed by trained professionals.

Section 5 — Health Effects Information

This section describes the nature of the hazardous effect resulting from exposure if no first aid or improper first aid is given. The primary routes of exposure such as eye, skin, inhalation or ingestion are listed along with the effects that could occur from acute (single) exposure and chronic (repeated) exposure. The most likely exposure for our products would be due to unsafe practices which result in skin or eye contact from splashes during handling or feeding of the product.

Section 6 — Toxicology Information

Our health hazard evaluation for a product is based upon one or more of the following:

1. Results of toxicological tests conducted on a product.
2. Toxicological test results for a product ingre
3. Use of test results on a similar formulation and,
4. Use of information obtained in the open lite supplier information for an ingredient(s).

In this Section, we present summaries of resu toxicity tests. Explanations of results are giver In most cases, results are those from acute, si exposure tests conducted with laboratory anim it should be remembered that the test proced quite stringent so that direct extrapolation of comparable human exposure must be viewed context.

The types of acute animal tests which are rou ducted include oral, dermal and inhalation leth and eye and skin irritancy studies. The lethali involve administration of the chemical to grou animals at various graded dose levels and rec tality as one end point. The mortality-dose re for the calculation of the LD_{50} or LC_{50} by app statistical methods. The LD_{50} is that dose (am chemical usually expressed in grams or millier kilogram of animal body weight (g/kg or mg/ka would produce death in one half of a group o administered the chemical. The LC_{50} is equiva except it uses concentration rather than dose a expressed as parts per million (ppm), milligram (mg/l) or milligrams per cubic meter of air (mg and dermal tests use LD_{50} while inhalation tes In both cases the smaller the value the more chemical.

Eye and skin irritancy tests utilize weighted nu scores to assess degree of injury or irritation. I instances, such numerical scores are also given ratings such as mildly or severely irritating. Mo systems are modeled after those described by (referred to in the Bibliography, Section 7) in original eye and skin irritation test procedures.

Results of skin sensitization tests conducted on animals are presented. Human data is given if Generally, these test results will be for one or m chemicals in a formulation rather than the form itself.

When available and applicable, results of tests to assess hazards other than lethality, will be p this Section under — "other toxicity results" an studies." These types of tests include life-time studies, reproduction tests, and tests designed birth defects (teratology studies). These tests ar conducted on individual chemical(s) rather than mulated products.

Other short-term bioassays for changes to gene run with bacterial and other cells. While these t identify genetic changes in tissue, the usefulness information as a prediction of a similar effect to

continues to be a scientific uncertainty. If this data is available, it will be provided in this section.

Since OSHA has broadened the criteria for acute health hazards and since the numerical rating is not uniformly accepted by all governmental agencies and scientific bodies, we are including OSHA's definitions below:

Highly toxic substance is one having:

1. An oral LD_{50} of 50 mg/kg or less.
2. A dermal LD_{50} of 200 mg/kg or less.
3. An inhalation LC_{50} of 200 ppm or less of gas or vapor; or 2 mg/l or less of mist, fume or dust.

A *toxic* substance is one having:

1. An oral LD_{50} between 50 and 500 mg/kg.
2. A dermal LD_{50} between 200 and 1000 mg/kg.
3. An inhalation LC_{50} between 200 ppm, 2,000 ppm of gas or vapors, or between 2 and 20 mg/l of mist, fume or dust.

A *corrosive* substance is one which causes third degree burns and scar tissue from 4-hour skin contact to rabbits.

A *skin irritant* is one which causes redness and swelling which does not persist and results in a numerical score of 5 out of 8 in greater than 50% of the animals tested.

An *eye irritant* — under 1910.1200 an eye irritant is one which at a minimum results in a grade 2 redness and/or swelling of the conjunctiva in at least 4 of 6 test animals when tested by the methods described in 16CFR 1500.42 or other appropriate techniques. The maximum attainable score using the Draize procedure is 110 (80 for cornea, 10 for iris, and 20 for conjunctiva).

Use of a finite irritation index to assess a chemical's potential as an eye irritant, i.e. x/110 cannot always be made because of inconsistencies between OSHA's definition and the standard Draize scoring technique. In some instances, an index as low as 2.7/110 is sufficient to warrant the eye irritation hazard statement while in other instances an index of 6/110 would not. In cases of conflict such as this we will point them out on the MSDS.

This rating system tends to classify many substances as irritants which would not be so classified under other regulations.

Section 7 — Physical and Chemical Properties

To assess the physical hazards of our products, we perform appropriate tests using procedures recommended by the American Society for Testing and Materials (ASTM). Their procedure number is identified accordingly. The tests vary depending on the physical form and chemical nature of the product. These physical or chemical test results are one of the factors reviewed in determining the need for or type of subsequent toxicological testing. The results are also used to identify hazardous physical properties which require labeling according to the Department of Transportation (DOT) regulations or for waste classification for disposal under the Resource Conservation and Recovery Act (RCRA).

Section 8 — Fire and Explosion Information

If the product exhibits flammable characteristics, information is provided on the recommended method for fighting fire. Unusual fire or explosion hazards are also given. OSHA 29CFR 1910.1200 and the Department of Transportation (DOT) consider products with flash points of less than 100 degrees Fahrenheit (F) as flammable materials. Chemicals with flash points between 100 degrees F and 200 degrees F are classified as combustible. On the other hand, the Resource Conservation and Recovery Act (RCRA) — 40CFR 261 subpart C and D define those chemicals with flash points of 140 degrees F and below as ignitable.

Section 9 — Reactivity Information

The potential for our products to aggressively react with other commonly found chemicals or to decompose represents a special hazard. Information is provided on possible interaction with other chemicals as well as reaction of our products on commonly encountered materials of construction used for chemical and feeding handling systems.

Section 10 — Personal Protective Equipment

Handling chemicals such as attaching feed pumps or transferring chemicals from one container to another constitutes the most likely exposure to operating personnel.

Recommendations are provided to protect personnel handling product spills, the type of ventilation needed, and the protective equipment (respirator, gloves, goggles, etc.) that should be used. This is one of the most important sections of the MSDS and the overall hazard communication program and should be well understood and put in practice by operating personnel.

Section 11 — Spill and Disposal Information

The disposal of wastes generated at a facility is one of the biggest problems facing industry. This section provides information on how to handle and clean up product spills and guidance for proper disposal should our product be considered a "waste" intended for disposal.

Section 12 — Environmental Information

This section provides information useful for assessing environmental impact of products or product constituents. When available and where applicable, information on partition coefficients, Biochemical Oxygen Demand (BOD), and Chemical Oxygen Demand (COD) is presented.

'ilts of acute aquatic bioassays are presented. These ' 'says, usually conducted on rainbow trout and bluegill ..ish are useful in assessing potential for adverse effects on aquatic vertebrates. Results are usually expressed as 96-hour LC_{50} values in milligrams per liter water (mg/l) or parts per million (ppm). The LC_{50} is the concentration which is lethal to 50% of a group of fish exposed for the time period indicated. It is synonymous with the term TL_{50} (the concentration which would result in the survival of 50% of a given test group). In many instances, 24 and 48 hours LC_{50} values are given. When applicable, a 96-hour, no-observed effect concentration is presented based upon lack of adverse effects and mortality.

While we know of no published list which ascribes a descriptive rating to LC_{50} values, listed below are ratings we use as internal guidelines:

96-Hour LC_{50}	Rating
<1.0 ppm	Extremely toxic
>1.0<5.0	Highly toxic
>5<10.0	Toxic
>10<100	Moderately toxic
>100<1000	Slightly toxic
>1000	Essentially non-toxic

Section 13 — Transportation Information

azardous chemicals are subject to regulation by the ..rtment of Transportation (DOT). Section 13 identifies the DOT proper shipping name and hazard class for the product, if any. This name will appear on all shipping documents. Many times the name will reflect the hazard and not necessarily the exact chemical name identified in Section 2. DOT hazard classifications are not always in agreement with those of OSHA.

Section 14 — Regulatory Information

Today chemical products are regulated from the time they are manufactured, during use, should any environmental release occur, and when the material is finally ready for disposal. Section 14 provides information on the status of our products under the various federal and state regulations that may govern its manufacture, use or disposal. Specifically, under the OSHA Hazard Communication Rule 29CFR 1910.1200, the reason for classifying the product as being hazardous is provided. A "hazardous classification" is triggered by such things as 1) being combustible (flash point 100–200 degrees F), 2) being flammable (flash point less than 100 degrees F), 3) being a skin or an eye irritant, 4) presenting chronic health hazards such as liver damage, nerve damage, etc., 5) listed on the National Toxicology Program (NTP) Annual Report on Carcinogens or found to be a potential carcinogen by the ' 'rnational Agency for Research on Cancer (IARC), 6) or A having an established workplace exposure limit or ,mmended limits. Threshold Limit Value (TLV) can be established by either OSHA [OSHA uses the term Permissible Exposure Limit (PEL)], the American Conference of Governmental Industrial Hygienists (ACGIH) or by the chemical manufacturer.

Three categories of TLV's are recognized: 1) the Threshold Limit Value-Time Weighted Average (TLV-TWA) – the time-weighted average concentration for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed day after day, without adverse effect, 2) Threshold Limit Value-Short Term Exposure Limit (TLV-STEL) – the concentration to which workers can be exposed continuously for a short period of time without suffering from a) irritation, b) chronic or irreversible tissue damage, or c) narcosis of sufficient degree to increase the likelihood of accidental injury, impair self-rescue or materially reduce work efficiency, and provided that the daily TLV-TWA is not exceeded. A STEL is defined as a 15-minute time-weighted average exposure which should not be exceeded at any time during a workday even if the 8-hour time-weighted average is within the TLV and 4) Threshold Limit Value-Ceiling (TLV-C) — the concentration that should not be exceeded during any part of the working exposure.

We frequently receive questions on the status of our products under other federal environmental laws. For this reason, when applicable, we are providing information on product status under major laws.

1. ***OSHA Hazard Communication 29CFR 1910.1200*** — These regulations have been discussed previously in this document.

2. ***Other OSHA Regulations*** — OSHA has established specific regulations for various chemicals. If these regulations apply to our products, the regulation and its applicability is identified.

3. ***CERCLA/Superfund 40CFR 117.302*** — This Law requires the reporting of spills of certain chemicals when the quantity spilled exceeds certain specified amounts. If Nalco's product contains one of the specified chemicals, the quantity of Nalco product which must be spilled before the notification requirement is "triggered," is calculated and the chemical is identified.

4. ***Toxic Substances Control Act (TSCA)*** — Only substances that are included on the TSCA 8(b) inventory list, have been exempted, or have been cleared through a TSCA premanufacturing notification (PMN) can be legally manufactured and used in the U.S.A. As other sections of TSCA are implemented, other regulations may apply and will be addressed.

NALCO

5. ***If our product requires registration or governmental clearances*** for use in intended applications (examples, pesticides under FIFRA, food additives under FDA, drinking water additives, fuel additives under EPA, use in meat and poultry plants under USDA) the status under the appropriate law is indicated.

6. ***Resource Conservation and Recovery Act (RCRA)*** — Our products as sold are not wastes and therefore not covered by this Act. However, should someone decide to declare them a waste and discard them, then they must be evaluated to determine how RCRA might cover the waste. This information is provided on our products should they become "a waste." Please refer to comments in Section 3 of this document regarding empty containers.

7. ***The Federal Clean Air and Water Acts 40CFR 60 and 61 and 40CFR 401.15 and 116*** contain sections which specifically list chemicals for which these regulations apply. If Nalco products contain as ingredients any of the chemicals listed under these sections, they will be identified. This will allow assessment of their impact, if any, on discharge or emission permits.

We also get similar questions regarding the status of our products under state regulations. State laws are becoming more common and it is difficult to cover all the specifics of each state law in this limited space. However, many states (such as Michigan) list those materials which they consider hazardous or use criteria for listing chemicals. Examples of these criteria are the established TLV's by OSHA or ACGIH or the presence of the chemical on a list such as the National Toxicology Program (NTP) Annual Report or International Agency for Research on Cancer (IARC) list for suspect carcinogens. We are identifying those chemicals for which there is an established TLV or that appear on the NTP or IARC lists.

Section 15 — Additional Information

There may be additional information available than what is covered in other sections affecting health, safety and regulation of our product. Section 15 provides space to present this additional information.

Section 16 — User's Responsibility

This section is designed to serve as a reminder that the information provided is of use only if it is transmitted to the persons who handle the product or work in locations where hazardous chemicals are used or stored. The information is developed based on recommended uses for our products. Other applications may warrant additional review.

Section 17 — Bibliography

In addition to this MSDS section description, we may find it of value to know the source material used in evaluating our products other than specific toxicity tests or physical/chemical tests we may have performed. The references below along with this document serve as a brief description of the hazard determination procedure we use in evaluating our products.

Typical Bibliographic Sources Used

Annual Report on Carcinogens, U.S. Department of Health and Human Services, Public Health Service, PB 33-135855, 1983.

Casarett and Doull's Toxicology, The Basic Science of Poisons, Doull, J., Klaassen, C. D., and Amdur, M. O., eds., Macmillian Publishing Company, Inc., N.Y., 2nd edition, 1980.

Chemical Hazards of the Workplace, Proctor, N. H., and Hughes, J. P., eds., J. P. Lipincott Company, N.Y., 1981.

Dangerous Properties of Industrial Materials, Sax, N. Irving, ed., Van Nostrand Reinhold Company, N.Y., 6th edition, 1984.

IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man, Geneva: World Health Organization, International Agency for Research on Cancer, 1972-1977.

Patty's Industrial Hygiene and Toxicology, Clayton, G. D., Clayton, F. E., eds., John Wiley and Sons, N.Y., 3rd edition, *Vol. 2 A-C*, 1981.

Registry of Toxic Effects of Chemical Substances, U.S. Department of Health and Human Services, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, 1983 supplement of 1981-1982 edition, *Vol. 1-3*, OH, 1984.

Title 29 Code of Federal Regulations Part 1910, Subpart Z, Toxic and Hazardous Substances, Occupational Safety and Health Administration (OSHA).

Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes, American Conference of Governmental Industrial Hygienists, OH.

MEMSTOR

MEMBRANE STORAGE AGENT

replaces formalin, sodium metabisulfite, and other chemicals for prevention of microbiological growth without creating an environmental or health hazard

the Product

MEMSTOR is a highly effective agent used for the short and long term storage of RO and UF membranes. It replaces the use of formaldehyde, sodium metabisulfite, and all other chemicals used in the prevention of microbiological growth within membrane cartridges. Its use does not create an environmental or health hazard. MEMSTOR does not lose efficacy as does metabisulfite, nor does it create toxic vapors like formaldehyde. It is non-reactive with membrane polymers and will not degrade membrane per- formance. MEMSTOR is available as a Six PAK (6X1lb preweighed polybags) or in a 25lb polylined drum.

the Features

1. Safe to use and discharge
2. Provides maximum membrane protection against the damaging effects of micro-organism growth within membrane devices
3. pH adjusted to maintain optimum membrane storage environment
4. Does not lose efficacy when membranes are stored for extended periods of time
5. Rinses quickly from membranes and system components
6. Packaged as a dry, stable, non-reactive powder

the Comparison - MEMSTOR/FORMALIN

	MEMSTOR	*FORMALIN*
1. Safety	Not caustic	Caustic to eyes, lungs, skin
2. Handling	No handling required Preweighed packages	Special requirements
3. Storage	Stable	Special requirements, unstable, Loses efficacy when diluted
4. Disposal	None	Special requirements
5. Environmental	No impact	Impacts ecology

use Instructions

MEMSTOR can be used for element storage in-place or in an outside container. Outside storage requires a drum or tank of sufficient dimensions to contain the number of elements that are to be stored.

IN-PLACE-STORAGE

1. Clean the membranes with cleaners (Diamite LPH, Diamite ACA or AFT) prior to storage. This is a necessary step to ensure a clean membrane surface.
2. Using good quality water (RO product water), mix at a ratio of one pound MEMSTOR or 1 package from MEMSTOR Six PAK to 4 gallons water.
3. Recirculate storage solution, at low pressure (less than 60psig), through membranes for a minimum of 15 minutes.
4. After recirculation, shut system down making sure storage solution does not drain out of membranes.
5. After storage, rinse membranes with good quality water for 30 minutes before system start-up.

CONTAINER-STORAGE

1. Clean the membranes with cleaners (Diamite LPH, Diamite ACA or AFT) prior to storage. This is a necessary step to ensure a clean membrane surface. (Clean in-place or on a cleaning skid)
2. Using good quality water (RO product water), mix at a ratio of one pound MEMSTOR or 1 package from MEMSTOR Six PAK to 6 gallons water.
3. Place membranes in storage container containing MEMSTOR solution.
4. After storage, place membranes in system and rinse with good quality water for 30 minutes prior to system start-up.

ARGO SCIENTIFIC
939 BAILEY COURT, SUITE A
SAN MARCOS, CALIFORNIA 92069
(619) 471-2650 FAX (619) 471-2369

PROGARD SPC™
MEMBRANE PRESERVATIVE

- Thin film and CA preservative
- FDA approved active ingredient
- Quick flush out
- Safe to drain
- Effective biostatic control

PROGARD SPC™ is a special formula designed to preserve thin film and cellulose acetate membranes during storage conditions. The active ingredient in PROGARD SPC™ is an antimicrobial agent which exhibits long-lasting bacteriostatic properties.

PROGARD SPC™ use instructions:

PROGARD SPC™ should be mixed with deionized or reverse osmosis product water in a 4-to-1 solution (4 parts RO or DI water to 1 part PROGARD SPC™).

Systems which have been in storage for prolonged periods of time (longer than four weeks) should be cleaned prior to start-up.

MATERIAL SAFETY DATA SHEET

ARGO SCIENTIFIC
935 Bailey Court
San Marcos, CA 92069

EMERGENCY PHONE (619) 471-2650

Effective date: 8/89 MSDS No. 57-55-6

Product name: PROGARD SPC™

Chemical name and synonyms: N/A

Chemical family: Glycol/$C_9H_{10}O_3$

Formula: Trade secret

1. HAZARDOUS COMPONENTS: None

2. PHYSICAL PROPERTIES

Boiling point:	212° F
Specific gravity:	1.04
Vapor pressure:	Approx 17.6
Percent volatile:	None
Vapor density:	Greater than 1
Evaporation rate:	Less than 1
Water solubility:	>99%
pH (3% Solution):	5.5 ± 0.5
Appearance & odor:	Colorless liquid Mild odor

3. FIRE & EXPLOSION DATA

Flash point: 212°F (PMCC)

Extinguishing media: Water, foam, CO_2, dry chemical

Special fire fighting procedures: Self-contained breathing apparatus recommended for fires involving this product.

Unusual fire and explosion hazards: None known

4. REACTIVITY

Stability: Stable

Incompatibility: None known

Hazardous decomposition products: None known

Hazardous polymerization: Will not occur

5. ENVIRONMENTAL AND DISPOSAL INFORMATION

Bury or incinerate in accordance with all Federal, State & local regulations.

Waste disposal method: Soak up with sand or other suitable absorbent and shovel into suitable waste container.

6. HEALTH HAZARD DATA

Eye contact:	Mild irritant
Skin contact:	Mild irritant
Inhalation:	Minimal irritant

7. FIRST AID

Eyes:	Flush with water. GET MEDICAL ATTENTION
Skin:	Flush with water
Ingestion:	Get water to dilute. GET MEDICAL ATTENTION
Inhalation:	Remove from contact area

8. HANDLING PRECAUTIONS

Respiratory protection:	None required
Ventilation:	General ventilation
Protective gloves:	Non-absorbent chemical type
Other equipment:	Safety glasses or goggles

9. ADDITIONAL INFORMATION

Special precautions to be taken in handling and storage: None

Other precautions: None

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TWX: (910) 262-3052 Aldrichem MI
Telex: 26 843 Aldrich MI
FAX: (414) 273-4979

ATTN: SAFETY DIRECTOR
SEPARATION SYSTEMS TECHNOLOGIES INC
4901 MORENA BLVD
SUITE 809
SAN DIEGO CA 92117

DATE: 10/04/91
CUST#: 938350
PO#: 1904

MATERIAL SAFETY DATA SHEET

IDENTIFICATION

PRODUCT #: 24758-8 NAME: SALICYLIC ACID, 99%, A.C.S. REAGENT
CAS #:69-72-7
MF: C7H6O3

SYNONYMS
ACIDO SALICILICO (ITALIAN) * BENZOIC ACID, 2-HYDROXY- * O-HYDROXYBENZOIC ACID * 2-HYDROXYBENZOIC ACID * KERALYT * KYSELINA 2-HYDROXYBENZOOVA (CZECH) * KYSELINA SALICYLOVA (CZECH) * ORTHOHYDROXYBENZOIC ACID * RETARDER W * SA * SAX * VERRUGON *

TOXICITY HAZARDS

RTECS NO: VO0525000
SALICYLIC ACID

IRRITATION DATA

SKN-RBT 500 MG/24H MLD	BIOFX* 21-3/71
EYE-RBT 100 MG SEV	BIOFX* 21-3/71

TOXICITY DATA

ORL-RAT LD50:891 MG/KG	BIOFX* 21-3/71
SCU-RAT LD50:1250 MG/KG	SRTCAC 36(1-4),10,89
ORL-MUS LD50:480 MG/KG	HBTXAC 5,148,59
IPR-MUS LD50:300 MG/KG	GNRIDX 3,675,69
IVN-MUS LD50:184 MG/KG	YKKZAJ 91,550,71
ORL-CAT LD50:400 MG/KG	HBTXAC 5,148,59
ORL-RBT LD50:1300 MG/KG	NIIRDN 6,291,82

REVIEWS, STANDARDS, AND REGULATIONS
EPA FIFRA 1988 PESTICIDE SUBJECT TO REGISTRATION OR RE-REGISTRATION
FEREAC 54,4388,89
NOHS 1974: HZD 67680; NIS 39; TNF 6955; NOS 57; TNE 61410
NOES 1983: HZD 67680000; TNF 40; NIS 2133; NOS 59; TNE 51922; TFE 20096
EPA GENETOX PROGRAM 1988, POSITIVE: S CEREVISIAE-REVERSION
EPA GENETOX PROGRAM 1988, NEGATIVE: HISTIDINE REVERSION-AMES TEST
EPA TSCA CHEMICAL INVENTORY, JUNE 1990
EPA TSCA TEST SUBMISSION (TSCATS) DATA BASE, MARCH 1991

TARGET ORGAN DATA
SENSE ORGANS AND SPECIAL SENSES (TINNITUS)
BEHAVIORAL (SOMNOLENCE)
BEHAVIORAL (CONVULSIONS OR EFFECT ON SEIZURE THRESHOLD)
BEHAVIORAL (MUSCLE WEAKNESS)
CARDIAC (CHANGE IN RATE)
LUNGS, THORAX OR RESPIRATION (RESPIRATORY DEPRESSION)
MATERNAL EFFECTS (UTERUS, CERVIX, VAGINA)
MATERNAL EFFECTS (PARTURITION)
EFFECTS ON FERTILITY (POST-IMPLANTATION MORTALITY)
EFFECTS ON FERTILITY (LITTER SIZE)

CONTINUED ON NEXT PAGE

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CUST#: 938350
PO#: 1904

PRODUCT #: 24758-8
CAS #: 69-72-7
MF: C7H6O3

NAME: SALICYLIC ACID, 99%, A.C.S. REAGENT

TOXICITY HAZARDS

EFFECTS ON EMBRYO OR FETUS (EXTRA EMBRYONIC STRUCTURES)
EFFECTS ON EMBRYO OR FETUS (FETOTOXICITY)
SPECIFIC DEVELOPMENTAL ABNORMALITIES (CENTRAL NERVOUS SYSTEM)
SPECIFIC DEVELOPMENTAL ABNORMALITIES (CRANIOFACIAL)
SPECIFIC DEVELOPMENTAL ABNORMALITIES (MUSCULOSKELETAL SYSTEM)
SPECIFIC DEVELOPMENTAL ABNORMALITIES (OTHER DEVELOPMENTAL ABNORMALITIES)

ONLY SELECTED REGISTRY OF TOXIC EFFECTS OF CHEMICAL SUBSTANCES (RTECS) DATA IS PRESENTED HERE. SEE ACTUAL ENTRY IN RTECS FOR COMPLETE INFORMATION.

HEALTH HAZARD DATA

ACUTE EFFECTS
HARMFUL IF SWALLOWED, INHALED, OR ABSORBED THROUGH SKIN.
CAUSES EYE AND SKIN IRRITATION.
MATERIAL IS IRRITATING TO MUCOUS MEMBRANES AND UPPER RESPIRATORY TRACT.
CHRONIC EFFECTS
LABORATORY EXPERIMENTS HAVE SHOWN MUTAGENIC EFFECTS.
TARGET ORGAN(S):
CENTRAL NERVOUS SYSTEM
FIRST AID
IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES.
IN CASE OF CONTACT, IMMEDIATELY WASH SKIN WITH SOAP AND COPIOUS AMOUNTS OF WATER.
IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.
IF SWALLOWED, WASH OUT MOUTH WITH WATER PROVIDED PERSON IS CONSCIOUS. CALL A PHYSICIAN.
WASH CONTAMINATED CLOTHING BEFORE REUSE.

PHYSICAL DATA

BOILING PT: 211 C/20MM.
MELTING PT: 158 C TO 161 C
VAPOR DENSITY: 4.8
VAPOR PRESSURE: 1 MM @ 114 C
APPEARANCE AND ODOR
WHITE POWDER

CONTINUED ON NEXT PAGE

Belgium/Holland Aldrich Chemie ... 1030 Bruxelles/Brussel Telephone: Belgium 114747 Holland 080224748 ...
France Aldrich-Chimie S.a.r.l. 27, Fossé des Treize F-67000 Strasbourg Telephone: 88327010 Telex: 890076 Aldrich F FAX: 88751283
Italy Aldrich Chimica S.r.l. Via Pietro Toselli, 4 20127 Milano Telephone: 022613689 Telex: 320862 Aldrich I FAX: 022896301
Japan Aldrich Japan Kyodo Bldg. Shinkanda 10 Kanda-Mikuracho Chiyoda-Ku, Tokyo Telephone: 032580155 FAX: 032580157
Spain Aldrich Quimica Apt. de Correos 161 28100 Alcobendas (Madrid) Telephone: 916630977 Telex: 22189 SAQS-E FAX: 916638084
United Kingdom Aldrich Chemical Co. Ltd. The Old Brickyard, New Road Gillingham, Dorset SP8 4JL Telephone: 0747822211 Telex: 417238 Aldrch G FAX: 0747823779
West Germany Aldrich-Chemie GmbH & Co. KG D-7924 Steinheim Telephone: 7329970 Telex: 714838 Aldri D FAX: 07329987139/239

5047

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CUST#: 938350
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PRODUCT #: 24758-8 NAME: SALICYLIC ACID, 99%, A.C.S. REAGENT
CAS #:69-72-7
MF: C7H6O3

---------- FIRE AND EXPLOSION HAZARD DATA ----------

EXTINGUISHING MEDIA
WATER SPRAY.
CARBON DIOXIDE, DRY CHEMICAL POWDER OR APPROPRIATE FOAM.
SPECIAL FIREFIGHTING PROCEDURES
WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING TO PREVENT CONTACT WITH SKIN AND EYES.

---------- REACTIVITY DATA ----------

INCOMPATIBILITIES
STRONG OXIDIZING AGENTS
STRONG BASES
SENSITIVE TO LIGHT
HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS
TOXIC FUMES OF:
CARBON MONOXIDE, CARBON DIOXIDE

---------- SPILL OR LEAK PROCEDURES ----------

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED
WEAR SELF-CONTAINED BREATHING APPARATUS, RUBBER BOOTS AND HEAVY RUBBER GLOVES.
SWEEP UP, PLACE IN A BAG AND HOLD FOR WASTE DISPOSAL.
AVOID RAISING DUST.
VENTILATE AREA AND WASH SPILL SITE AFTER MATERIAL PICKUP IS COMPLETE.
WASTE DISPOSAL METHOD
DISSOLVE OR MIX THE MATERIAL WITH A COMBUSTIBLE SOLVENT AND BURN IN A CHEMICAL INCINERATOR EQUIPPED WITH AN AFTERBURNER AND SCRUBBER.

--- PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE ---

CHEMICAL SAFETY GOGGLES.
RUBBER GLOVES.
NIOSH/MSHA-APPROVED RESPIRATOR.
SAFETY SHOWER AND EYE BATH.
USE ONLY IN A CHEMICAL FUME HOOD.
DO NOT BREATHE DUST.
DO NOT GET IN EYES, ON SKIN, ON CLOTHING.
WASH THOROUGHLY AFTER HANDLING.
TOXIC.
IRRITANT.

CONTINUED ON NEXT PAGE

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CAS #:69-72-7
MF: C7H6O3

--- PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE ---

POSSIBLE MUTAGEN.
KEEP TIGHTLY CLOSED.
MOISTURE SENSITIVE
PROTECT FROM LIGHT.
STORE IN A COOL DRY PLACE.

LABEL PRECAUTIONARY STATEMENTS
TOXIC (USA DEFINITION)
HARMFUL (EUROPEAN DEFINITION)
HARMFUL BY INHALATION, IN CONTACT WITH SKIN AND IF SWALLOWED.
IRRITATING TO EYES, RESPIRATORY SYSTEM AND SKIN.
POSSIBLE RISK OF IRREVERSIBLE EFFECTS.
POSSIBLE MUTAGEN.
TARGET ORGAN(S):
CENTRAL NERVOUS SYSTEM
IN CASE OF CONTACT WITH EYES, RINSE IMMEDIATELY WITH PLENTY OF WATER AND SEEK MEDICAL ADVICE.
WEAR SUITABLE PROTECTIVE CLOTHING.
DO NOT BREATHE DUST.

THE ABOVE INFORMATION IS BELIEVED TO BE CORRECT BUT DOES NOT PURPORT TO BE ALL INCLUSIVE AND SHALL BE USED ONLY AS A GUIDE. ALDRICH SHALL NOT BE HELD LIABLE FOR ANY DAMAGE RESULTING FROM HANDLING OR FROM CONTACT WITH THE ABOVE PRODUCT. SEE REVERSE SIDE OF INVOICE OR PACKING SLIP FOR ADDITIONAL TERMS AND CONDITIONS OF SALE.

Pfizer

CHEMICAL DIVISION

INFORMATION SHEET 2050

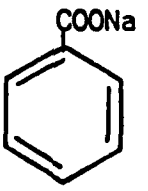
SODIUM BENZOATE NF,FCC

Sodium benzoate is the sodium salt of benzoic acid. Sodium benzoate is a white odorless, or nearly odorless, crystalline granule or powder with an astringent, sweetish taste. It is widely employed in the food industry as an antimicrobial agent. All three forms sold by Pfizer conform to the specifications set by the National Formulary and the Food Chemicals Codex.

Properties

Formula	$C_7H_5NaO_2$
Molecular Wt.	144.11
Solubility ($25^{\circ}C$)	g/100 ml
water	50
Alcohol	1.3
Ether	Insoluble

Structure



Pfizer supplies three types of Sodium Benzoate NF,FCC.

Powder (S 4144)
Dense (S 4148)
Type LD (S 4146)

The products differ in particle size, which has direct impact upon the solubility rate and dusting characteristics of the material.

Particle Size (USS Sieves)

Powder	2.0% Maximum on 80 mesh
Dense	1% Maximum on 8 mesh
	30% Maximum through 80 mesh
Type LD	15% Maximum on 8 mesh
	10% Maximum through 80 mesh

Comparative Rates of Dissolution*

Powder	1:45
Dense	3:00
Type LD	3:25

*Determined by measuring time required for 100 grams to dissolve in 300 ml water with controlled temperature and agitation. The absolute value of the data presented may vary because of sample selection and methodology; however, the order of ease of dissolution is predictable.

Sodium Benzoate Powder is recommended when rapid solubility is a critical factor in a process, and where dusting is not a problem.

Sodium Benzoate Type LD or "low dusting" is a very granular material with fewer fines present. Owing to the larger particle size, this material requires more time to go into solution. Type LD is recommended when a relatively low-dusting material is desired and for air-conveyor bulk-handling systems.

Pfizer's standard Sodium Benzoate Dense is recommended for most applications, particularly when solubility rate or moderate dusting is not a primary consideration.

Materials should be stored in well-closed containers.

Pfizer CHEMICAL DIVISION

235 EAST 42nd STREET, NEW YORK, N.Y. 10017

Branch Offices

230 Brighton Road
Clifton, N.J. 07012

2400 West Central Road.
Hoffman Estates, Ill. 60196

16700 Red Hill Avenue
Irvine, Calif. 92714

4360 Northeast Expressway
Doraville, Ga. 30340

September 1981

SC14735
SC14737

Mallinckrodt

SODIUM BORATE

Material Safety Data Sheet

Mallinckrodt Inc.
Science Products Division
P.O. Box M
Paris, Kentucky 40361

Emergency Telephone Number
314-982-5000

Effective Date: 10-15-85

PRODUCT IDENTIFICATION:

Synonyms: Sodium borate decahydrate; borax; sodium pyroborate

Formula CAS No.: 1303-96-4 (Hydrate)
TSCA CAS No.: 1330-43-4 (Anhydrous)

Molecular Weight: 381.37

Chemical Formula: $Na_2B_4O_7 \cdot 10H_2O$

Hazardous Ingredients:
Not applicable.

PRECAUTIONARY MEASURES

WARNING! HARMFUL IF SWALLOWED, INHALED OR ABSORBED THROUGH SKIN.
MAY CAUSE IRRITATION TO SKIN, EYES AND RESPIRATORY TRACT.

Avoid contact with eyes, skin and clothing.
Avoid breathing dust.
Keep container closed.
Use with adequate ventilation.
Wash thoroughly after handling.

EMERGENCY/FIRST AID

If swallowed, induce vomiting immediately by giving two glasses of water and sticking finger down throat. Never give anything by mouth to an unconscious person.
If inhaled, remove to fresh air. Get medical attention for any breathing difficulty.
In case of contact, immediately flush skin or eyes with plenty of water for at least 15 minutes.
In all cases call a physician.
SEE SECTION 5.

DOT Hazard Class: Not Regulated

Physical Data — SECTION 1

Appearance: Grey, blue, or green crystals.

Odor: Odorless.

Solubility: 6g/100g water.

Boiling Point: Loses water @ 320°C (608°F).

Melting Point: 75°C (167°F).

Density: 1.73

Vapor Density (Air=1): No information found.

Vapor Pressure (mm Hg): No information found.

Evaporation Rate: No information found.

Fire and Explosion Information — SECTION 2

Fire: Not considered to be a fire hazard.

Explosion: Not considered to be an explosion hazard.

Fire Extinguishing Media: Use any means suitable for extinguishing surrounding fire.

Special Information: In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode.

Reactivity Data — SECTION 3

Stability: Stable under ordinary conditions of use and storage.

Hazardous Decomposition Products: Emits toxic fumes of sodium oxide when heated to decomposition.

Hazardous Polymerization: Will not occur.

Incompatibilities: Acids, alkaloids, and metallic salts.

Leak/Spill Disposal Information — SECTION 4

Ventilate area of leak or spill. Clean-up personnel may require respiratory protection from dust.

Spills: Sweep up and containerize for reclamation or disposal. Vacuuming or wet sweeping may be used to avoid dust dispersal.

Disposal: Whatever cannot be saved for reclamation may be delivered to an approved waste disposal facility.

Ensure compliance with local, state and federal regulations.

Health Hazard Information — SECTION 5

A. Exposure/Health Effects

Inhalation: May cause irritation to the respiratory tract, coughing, nausea, and vomiting.

Ingestion: May cause nausea, vomiting, diarrhea, muscular spasms, dullness, lethargy, circulatory depression, central nervous system depression, shock, kidney damage, coma, and death. Estimated lethal dose 15 to 20 grams.

Skin Contact: May cause irritation. May be absorbed through the skin, especially damaged skin, with symptoms paralleling ingestion.

Eye Contact: May cause irritation, redness, and pain.

Chronic Exposure: Prolonged or repeated ingestion or skin absorption may cause anorexia, weight loss, vomiting, mild diarrhea, skin rash, convulsions, and anemia.

Aggravation of Pre-existing Conditions: No information found.

B. FIRST AID

Inhalation: Remove to fresh air. Get medical attention for any breathing difficulty.

Ingestion: If swallowed, induce vomiting immediately by giving two glasses of water and sticking finger down throat. Never give anything by mouth to an unconscious person. Call physician immediately.

Skin Exposure: In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Call a physician.

Eye Exposure: Wash eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

C. TOXICITY DATA (RTECS, 1982)

Oral rat LD50: 2660 mg/kg.
Mutation references cited.
Reproductive effects cited.

Occupational Control Measures — SECTION 6

Airborne Exposure Limits: -ACGIH Threshold Limit Value (TLV): 5 mg/m^3 (TWA)

Ventilation System: A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, "Industrial Ventilation, A Manual of Recommended Practices", most recent edition, for details.

Personal Respirators (NIOSH Approved): If the TLV is exceeded, a dust/mist respirator with chemical goggles may be worn, in general, up to ten times the TLV. Consult respirator supplier for limitations. Alternatively, a supplied air full facepiece respirator or airlined hood may be worn.

Skin Protection: Wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls to prevent skin contact.

Eye Protection: Use chemical safety goggles. Contact lenses should not be worn when working with this material.

Maintain eye wash fountain and quick-drench facilities in work area.

Storage and Special Information — SECTION 7

Keep in a tightly closed container, stored in a cool, dry, ventilated area. Protect against physical damage.

SUBSTANCE IDENTIFICATION

CAS-NUMBER 7631-90-5

SUBSTANCE: SODIUM BISULFITE

TRADE NAMES/SYNONYMS:
SULFUROUS ACID, MONOSODIUM SALT; FR-62; HYDROGEN SODIUM SULFATE; HYDROGEN SULFITE SODIUM; MONOSODIUM SULFITE; SODIUM ACID SULFITE; SODIUM BISULPHITE; SODIUM HYDROGEN SULFITE; SODIUM SULFITE; STCC 4944155; S-654; UHS21000

CHEMICAL FAMILY:
INORGANIC SALT

MOLECULAR FORMULA: NA-H-S-O3

MOLECULAR WEIGHT: 104.06

CERCLA RATINGS (SCALE 0-3): HEALTH=3 FIRE=0 REACTIVITY=0 PERSISTENCE=0
NFPA RATINGS (SCALE 0-4): HEALTH=3 FIRE=0 REACTIVITY=0

COMPONENTS AND CONTAMINANTS

COMPONENT: SODIUM BISULFITE PERCENT: 100

OTHER CONTAMINANTS: NONE

EXPOSURE LIMITS:
SODIUM BISULFITE:
5 MG/M3 OSHA TWA
5 MG/M3 ACGIH TWA

5000 POUNDS CERCLA SECTION 103 REPORTABLE QUANTITY

PHYSICAL DATA

DESCRIPTION: WHITE CRYSTALS OR CRYSTALLINE POWDER WITH A SLIGHT SULFUROUS ODOR AND TASTE. BOILING POINT: DECOMPOSES MELTING POINT: DECOMPOSES

SPECIFIC GRAVITY: 1.48 PH: ACIDIC IN SOLUTION

SOLUBILITY IN WATER: SOLUBLE

SOLVENT SOLUBILITY: SLIGHTLY SOLUBLE IN ALCOHOL

FIRE AND EXPLOSION DATA

FIRE AND EXPLOSION HAZARD:
NEGLIGIBLE FIRE HAZARD WHEN EXPOSED TO HEAT OR FLAME.

FIREFIGHTING MEDIA:
DRY CHEMICAL, CARBON DIOXIDE, HALON, WATER SPRAY OR STANDARD FOAM (1987 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.4).

FOR LARGER FIRES, USE WATER SPRAY, FOG OR STANDARD FOAM (1987 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.4).

FIREFIGHTING:
MOVE CONTAINERS FROM FIRE AREA IF POSSIBLE. COOL CONTAINERS EXPOSED TO FLAMES WITH WATER FROM SIDE UNTIL WELL AFTER FIRE IS OUT. STAY AWAY FROM STORAGE TANK ENDS (1987 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.4, GUIDE PAGE 60).

USE AGENTS SUITABLE FOR TYPE OF FIRE. USE WATER IN FLOODING AMOUNTS AS FOG. COOL CONTAINERS WITH FLOODING AMOUNTS OF WATER, APPLY FROM AS FAR A DISTANCE AS POSSIBLE. AVOID BREATHING CORROSIVE VAPORS, KEEP UPWIND.

TRANSPORTATION DATA

DEPARTMENT OF TRANSPORTATION HAZARD CLASSIFICATION 49CFR172.101:
ORM-B

DEPARTMENT OF TRANSPORTATION LABELING REQUIREMENTS 49CFR172.101 AND 172.402:
NONE

DEPARTMENT OF TRANSPORTATION PACKAGING REQUIREMENTS: 49CFR173.800
EXCEPTIONS: 49CFR173.505

TOXICITY

SODIUM BISULFITE:
2000 MG/KG ORAL-RAT LD50; 650 MG/KG INTRAPERITONEAL-RAT LD50; 115 MG/KG INTRAVENOUS-RAT LD50; 244 MG/KG INTRAPERITONEAL-DOG LD50; 779 MG/KG INTRAPERITONEAL-GUINEA PIG LD50; 575 MG/KG INTRAPERITONEAL-MOUSE LD50; 300 MG/KG INTRAPERITONEAL-RABBIT LD50; 130 MG/KG INTRAVENOUS-MOUSE LD50; 65 MG/KG INTRAVENOUS-RABBIT LD50; MUTAGENIC DATA (RTECS).
CARCINOGEN STATUS: NONE.
SODIUM BISULFITE IS AN EYE, SKIN, AND MUCOUS MEMBRANE IRRITANT AND A SENSITIZER. ASTHMATICS MAY BE AT AN INCREASED RISK FROM EXPOSURE.

HEALTH EFFECTS AND FIRST AID

INHALATION:
SODIUM BISULFITE:
IRRITANT/SENSITIZER.
ACUTE EXPOSURE- MAY CAUSE IRRITATION WITH SORE THROAT, COUGHING, AND SHORTNESS OF BREATH. AQUEOUS SOLUTIONS MAY CAUSE SEVERE IRRITATION. SULFITES MAY CAUSE SENSITIZATION REACTIONS IN PREVIOUSLY EXPOSED PERSONS,

ESPECIALLY ASTHMATICS. SYMPTOMS MAY INCLUDE FLUSHING, SEVERE WHEEZING, SWELLING OF THE THROAT, AND GENERALIZED ITCHING.
CHRONIC EXPOSURE- REPEATED OR PROLONGED EXPOSURE MAY CAUSE SENSITIZATION.

FIRST AID- REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, PERFORM ARTIFICIAL RESPIRATION. KEEP PERSON WARM AND AT REST. TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY.

SKIN CONTACT:
SODIUM BISULFITE:
IRRITANT/SENSITIZER.
ACUTE EXPOSURE- CONTACT WITH THE SKIN MAY CAUSE IRRITATION. AQUEOUS SOLUTIONS MAY CAUSE SEVERE IRRITATION WITH POSSIBLE CORROSION. SENSITIZATION DERMATITIS MAY OCCUR IN PREVIOUSLY EXPOSED PERSONS.
CHRONIC EXPOSURE- REPEATED OR PROLONGED EXPOSURE MAY CAUSE CONTACT DERMATITIS. SENSITIZATION REACTIONS HAVE BEEN REPORTED ALSO.

FIRST AID- REMOVE CONTAMINATED CLOTHING AND SHOES IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

EYE CONTACT:
SODIUM BISULFITE:
IRRITANT.
ACUTE EXPOSURE- CONTACT WITH THE EYES MAY CAUSE IRRITATION. AQUEOUS SOLUTIONS MAY CAUSE SEVERE IRRITATION WITH POSSIBLE CORROSION.
CHRONIC EXPOSURE- REPEATED OR PROLONGED EXPOSURE MAY CAUSE CONJUNCTIVITIS.

FIRST AID- WASH EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER OR NORMAL SALINE, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

INGESTION:
SODIUM BISULFITE:
SENSITIZER.
ACUTE EXPOSURE- MAY CAUSE IRRITATION OF THE STOMACH WITH ABDOMINAL PAIN AND NAUSEA. THE ESTIMATED LETHAL DOSE IN HUMANS IS 10 GRAMS. IN SUSCEPTIBLE INDIVIDUALS, PARTICULARLY ASTHMATICS, SULFITES MAY CAUSE GENERALIZED FLUSHING, FAINTNESS, BRONCHOSPASMS WITH WHEEZING AND SHORTNESS OF BREATH, ANGIOEDEMA, HIVES, GENERALIZED ITCHING, LARYNGEAL EDEMA, HYPOTENSION, CYANOSIS, RAPID PULSE, COLD, CLAMMY SKIN, ANAPHYLAXIS, RESPIRATORY ARREST, AND UNCONSCIOUSNESS. INGESTION OF VERY LARGE DOSES OF SULFITES CAUSED VIOLENT COLIC AND DIARRHEA, CIRCULATORY DISTURBANCES, CENTRAL NERVOUS SYSTEM DEPRESSION, AND DEATH IN RATS.
CHRONIC EXPOSURE- REPEATED OR PROLONGED INGESTION OF FOODS CONTAINING SULFITES MAY CAUSE SENSITIZATION.

FIRST AID- DO NOT USE GASTRIC LAVAGE OR EMESIS. DILUTE THE ACID IMMEDIATELY BY DRINKING LARGE QUANTITIES OF WATER OR MILK. IF VOMITING PERSISTS, ADMINISTER FLUIDS REPEATEDLY. INGESTED ACID MUST BE DILUTED APPROXIMATELY 100 TIMES TO RENDER IT HARMLESS TO TISSUES. MAINTAIN AIRWAY AND TREAT SHOCK. (DREISBACH, HANDBOOK OF POISONING, 11TH ED.). GET MEDICAL ATTENTION IMMEDIATELY. IF VOMITING OCCURS, KEEP HEAD BELOW HIPS TO HELP PREVENT ASPIRATION.

ANTIDOTE:
NO SPECIFIC ANTIDOTE. TREAT SYMPTOMATICALLY AND SUPPORTIVELY.

REACTIVITY

REACTIVITY:
STABLE UNDER NORMAL TEMPERATURES AND PRESSURES IN AN ENCLOSED CONTAINER.
SLOWLY OXIDIZED TO THE SULFATE IN AIR.

INCOMPATIBILITIES:
SODIUM BISULFITE:
ACIDS (STRONG): RELEASES SULFUR DIOXIDE.
ALUMINUM: CORROSIVE.
OXIDIZERS: REACTS.

DECOMPOSITION:
THERMAL DECOMPOSITION MAY RELEASE TOXIC OXIDES OF SULFUR AND TOXIC SODIUM OXIDE.

POLYMERIZATION:
HAZARDOUS POLYMERIZATION HAS NOT BEEN REPORTED TO OCCUR UNDER NORMAL TEMPERATURES AND PRESSURES.

STORAGE AND DISPOSAL

OBSERVE ALL FEDERAL, STATE AND LOCAL REGULATIONS WHEN STORING OR DISPOSING OF THIS SUBSTANCE. FOR ASSISTANCE, CONTACT THE DISTRICT DIRECTOR OF THE ENVIRONMENTAL PROTECTION AGENCY.

STORAGE

STORE AWAY FROM INCOMPATIBLE SUBSTANCES.

****

CONDITIONS TO AVOID

NONE REPORTED.

****

SPILL AND LEAK PROCEDURES

SOIL SPILL:
DIG A PIT, POND, LAGOON OR HOLDING AREA TO CONTAIN LIQUID OR SOLID MATERIAL. COVER SOLIDS WITH A PLASTIC SHEET TO PREVENT DISSOLVING IN RAIN OR FIREFIGHTING WATER.

WATER SPILL:
NEUTRALIZE WITH CAUSTIC SODA.

ADD CALCIUM HYPOCHLORITE TO SPILL.

ADD SUITABLE AGENT TO NEUTRALIZE SPILLED MATERIAL TO PH-7.

OCCUPATIONAL SPILL:
SWEEP UP AND PLACE IN SUITABLE CLEAN, DRY CONTAINERS FOR RECLAMATION OR LATER

ISPOSAL. DO NOT FLUSH WITH WATER. KEEP UNNECESSARY PEOPLE AWAY.

EPORTABLE QUANTITY (RQ): 5000 POUNDS
HE SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT (SARA) SECTION 304 REQUIRES HAT A RELEASE EQUAL TO OR GREATER THAN THE REPORTABLE QUANTITY FOR THIS UBSTANCE BE IMMEDIATELY REPORTED TO THE LOCAL EMERGENCY PLANNING COMMITTEE ND THE STATE EMERGENCY RESPONSE COMMISSION (40 CFR 355.40). IF THE RELEASE OF HIS SUBSTANCE IS REPORTABLE UNDER CERCLA SECTION 103, THE NATIONAL RESPONSE ENTER MUST BE NOTIFIED IMMEDIATELY AT (800) 424-8802 OR (202) 426-2675 IN THE ETROPOLITAN WASHINGTON, D.C. AREA (40 CFR 302.6).

PROTECTIVE EQUIPMENT

ENTILATION:
ROVIDE LOCAL EXHAUST VENTILATION AND/OR GENERAL DILUTION VENTILATION TO MEET UBLISHED EXPOSURE LIMITS.

ESPIRATOR:
HE SPECIFIC RESPIRATOR SELECTED MUST BE BASED ON THE CONTAMINATION LEVELS FOUND IN THE WORK PLACE, MUST NOT EXCEED THE WORKING LIMITS OF THE RESPIRATOR AND BE JOINTLY APPROVED BY THE NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH AND THE MINE SAFETY AND HEALTH ADMINISTRATION.
HE FOLLOWING RESPIRATORS ARE RECOMMENDED BASED ON THE DATA FOUND IN THE PHYSICAL DATA, HEALTH EFFECTS AND TOXICITY SECTIONS. THEY ARE RANKED IN ORDER FROM MINIMUM TO MAXIMUM RESPIRATORY PROTECTION:

DUST AND MIST RESPIRATOR WITH A FULL FACEPIECE.

AIR-PURIFYING FULL FACEPIECE RESPIRATOR WITH A HIGH-EFFICIENCY PARTICULATE FILTER.

POWERED AIR-PURIFYING RESPIRATOR WITH A TIGHT-FITTING FACEPIECE AND HIGH-EFFICIENCY PARTICULATE FILTER.

TYPE 'C' SUPPLIED-AIR RESPIRATOR WITH A FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE OR WITH A FULL FACEPIECE, HELMET OR HOOD OPERATED IN CONTINUOUS-FLOW MODE.

SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE.

FOR FIREFIGHTING AND OTHER IMMEDIATELY DANGEROUS TO LIFE OR HEALTH CONDITIONS:

SELF-CONTAINED BREATHING APPARATUS WITH FULL FACEPIECE OPERATED IN PRESSURE DEMAND OR OTHER POSITIVE PRESSURE MODE.

SUPPLIED-AIR RESPIRATOR WITH FULL FACEPIECE AND OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE IN COMBINATION WITH AN AUXILIARY SELF-CONTAINED BREATHING APPARATUS OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE.

CLOTHING:
EMPLOYEE MUST WEAR APPROPRIATE PROTECTIVE (IMPERVIOUS) CLOTHING AND EQUIPMENT TO PREVENT REPEATED OR PROLONGED SKIN CONTACT WITH THIS SUBSTANCE.

MATERIAL SAFETY DATA SHEET

EASTMAN KODAK COMPANY
343 State Street
Rochester, New York 14650

DATE: 09/20/91
PO NBR: R38460
ACCT: 70158002
INDEX: 28912620184
CAT NO: EK118061 1
SHEET: R-0325.300

For Emergency Health, Safety, and Environmental Information, call 800-225-5352, in New York State call 716-458-4014
For all other purposes, call 800-225-5352, in New York State call 716-458-4014

Date of Preparation: 10/21/86 Kodak Accession Number: 905822

SECTION I. IDENTIFICATION

- Product Name: Sorbic Acid
- Synonym(s): (E,E)-2,4-Hexadienoic Acid
- Formula: C6 H8 O2
- CAT No(s): 118 0595; 118 0603; 118 0611
- Chem. No(s): 05822
- Kodak's Internal Hazard Rating Codes: R: 1 S: 2 F: 1 C: 0

SECTION II. PRODUCT AND COMPONENT HAZARD DATA

COMPONENT(S):	Percent	ACGIH TLV(R)	CAS Reg. No.
Sorbic Acid	ca. 100	---	110-44-1

SECTION III. PHYSICAL DATA

- Appearance: Fine white powder
- Melting Point: 135 C (275 F)
- Vapor Pressure: Negligible
- Evaporation Rate (n-butyl acetate = 1): Negligible
- Volatile Fraction by Weight: Negligible
- Specific Gravity (Water = 1): 1.20
- Solubility in Water (by Weight): Negligible

SECTION IV. FIRE AND EXPLOSION HAZARD DATA

- Flash Point: Not Applicable
- Extinguishing Media: Water spray; Dry chemical; Carbon dioxide
- Special Fire Fighting Procedures: Wear self-contained breathing apparatus and protective clothing.
- Unusual Fire and Explosion Hazards: This material in sufficient quantity and reduced particle size is capable of creating a dust explosion.

SECTION V. REACTIVITY DATA

Stability: Stable
Incompatibility: Strong oxidizers, reducing agents, bases
Hazardous Decomposition Products: Combustion will produce carbon dioxide and probably carbon monoxide.

- Hazardous Polymerization: Will not occur.

SECTION VI. TOXICITY AND HEALTH HAZARD DATA

A. EXPOSURE LIMITS: Not established.

B. EXPOSURE EFFECTS:
Inhalation: Low hazard for usual industrial handling.
Skin: Causes irritation. May cause allergic skin reaction.
Eye: No specific hazard known. Contact may cause transient irritation.
Ingestion: Expected to be a low ingestion hazard.

C. FIRST AID:
Inhalation: Remove to fresh air following overexposure.
Skin: Immediately flush skin with plenty of water for at least 15 minutes. Get medical attention if symptoms are present after washing.
Eye: Flush eyes with plenty of water.
Ingestion: Drink 1-2 glasses of water. Seek medical advice.

SECTION VII. VENTILATION AND PERSONAL PROTECTION

A. VENTILATION AND RESPIRATORY PROTECTION:
Good ventilation should be sufficient. Supplementary ventilation or respiratory protection may be needed in special circumstances.

B. SKIN AND EYE PROTECTION:
Protective gloves and clothing should be worn. Safety glasses should be worn.

SECTION VIII. SPECIAL STORAGE AND HANDLING PRECAUTIONS

Keep from contact with oxidizing materials. Keep container tightly closed and away from reducing agents or bases.

SECTION IX. SPILL, LEAK, AND DISPOSAL PROCEDURES

Sweep up material and package for safe feed to an incinerator. Dispose by incineration or contract with licensed chemical waste disposal agency. Discharge, treatment, or disposal may be subject to federal, state or local laws.

For transportation information regarding this material, please phone the Eastman Kodak Distribution Center nearest you: Rochester, NY (716) 254-1300; Oak Brook, IL (312) 654-5300; Chamblee, GA (404) 455-0123; Dallas, TX (214) 241-1611; Whittier, CA (213) 945-1255; Honolulu, HI (808) 833-1661.

The information contained herein is furnished without warranty of any kind. Users should consider these data only as a supplement to other information gathered by them and must make independent determinations of the suitability and completeness of information from all sources to assure proper use and disposal of these materials and the safety and health of employees and customers.

Product Safety Information

QUESTEX® 4SW

Tetrasodium Ethylenediaminetetraacetate, Hydrate

This Product Safety Information Sheet is principally directed to managerial, safety, hygiene and medical personnel. The description of physical, chemical and toxicological properties and handling advice is based on experimental results and past experience. It is intended as a starting point for the development of safety and health procedures.

I. PHYSICAL AND CHEMICAL PROPERTIES

Formula: $C_{10}H_{12}N_2Na_4O_8 \cdot 4H_2O$
Formula Weight: 452.2 (Na_4EDTA)
Physical State: White crystalline solid
Water Solubility: 103 gm/100 gm H_2O @ 25°C/77°F
pH: 10.5-11.5 (1% aqueous solution)
Bulk Density: Approximately 45 lbs./ft.^{3}
Odor: None
Flash Point: None

II. CHEMICAL REACTIVITY

An aqueous solution of this product complexes soluble multivalent metal ions over a wide pH range. It reacts slowly with insoluble compounds containing metal ions. See Section X for information regarding chemical reactivity with metals.

III. STABILITY

This material is degraded by strong oxidizing agents such as chromic acid, potassium permanganate and high concentrations of hydrogen peroxide. Prolonged heating or storage at temperatures greater than 200°C/392°F will result in loss of water of hydration.

IV. FIRE HAZARD

This material is not considered combustible, nor will it support combustion.

V. FIREFIGHTING TECHNIQUE

As in any fire prevent human exposure to fire, smoke, fumes, or products of combustion. Evacuate nonessential personnel from the fire area.

When there is a potential for exposure to fire, smoke, fumes, products of combustion, etc., firefighters should wear full-face, self-contained breathing apparatus and impervious clothing such as gloves, hoods, suits and rubber boots.

Use standard firefighting techniques in extinguishing fires involving this material—use water, dry chemicals, foam, carbon dioxide or other suitable suffocation agents.

VI. TOXICOLOGY

CAUTION: Prolonged or repeated contact may cause irritation. Avoid contact with eyes, skin and clothing.

Ingestion
The acute oral LD50 is 630 to 1260 mg/kg in rats.

Skin Contact
Prolonged or repeated skin contact may cause slight redness. Nonirritant to skin following short-term contact.

Eye Contact
Moderate irritant to eyes. May cause slight transient corneal injury.

Threshold Limit Value (TLV)
The American Conference of Governmental Industrial Hygienists has not established a TLV.

VII. FIRST AID

CALL A PHYSICIAN IMMEDIATELY

If a known exposure occurs, or if poisoning is suspected, do not wait for symptoms to develop. Immediately initiate the recommended procedures below. Simultaneously contact a physician, or the nearest hospital, or the nearest Poison Control Center. Inform the person contacted of the type and extent of exposure, describe the victim's symptoms, and follow the advice given. For additional information, call collect, day or night, Stauffer Chemical Company (203) 226-6602 or Chemtrec (800) 424-9300.

Ingestion
If swallowed — Immediately dilute the swallowed material by giving large quantities of water. Induce vomiting by gagging the victim with a blunt object placed on the back of the victim's tongue. Continue fluid administration until vomitus is clear. Never give anything by mouth

In case of suspected poisoning, refer to the procedure and emergency contacts in Section VII — FIRST AID.
In case of spillage, refer to the procedure and emergency contacts in Section IX — SPILL HANDLING.
In case of animal poisoning, call a veterinarian or call collect, day or night (203) 226-6602 (Stauffer Chemical Company) or (800) 424-9300 (Chemtrec).
In case of contamination of other materials with this product, call (800) 424-9300 (Chemtrec).

Stauffer CHEMICALS
STAUFFER CHEMICAL COMPANY
INDUSTRIAL CHEMICAL DIVISION
Westport, Connecticut 06880

to an unconscious person. Call a physician or the nearest Poison Control Center immediately.

Eye Contact
Immediately flush the eyes with large quantities of running water for a minimum of 15 minutes. Hold the eyelids apart during the flushing to ensure rinsing of the entire surface of the eye and lids with water. Do not attempt to neutralize with chemical agents. Obtain medical attention as soon as possible. Oils or ointments should not be used. Continue the flushing for an additional 15 minutes if the physician is not immediately available.

Skin Contact
Remove any contaminated clothing and wash all affected areas with plenty of soap and water. Seek medical attention if irritation occurs.

Inhalation
Remove from contaminated atmosphere. If breathing has ceased, clear the victim's airway and start mouth-to-mouth artificial respiration, which may be supplemented by the use of a bag-mask respirator, or a manually-triggered, oxygen supply capable of delivering one liter/second or more. If the victim is breathing, oxygen may be delivered from a demand-type or continuous-flow inhalator, preferably with a physician's advice. Contact a physician immediately.

VIII. INDUSTRIAL HYGIENE

Ingestion
All food should be kept in a separate area away from the working location. Eating, drinking, and smoking should be prohibited in areas where there is a potential for significant exposure to this material. Before eating, hands and face should be thoroughly washed.

Skin Contact
Skin contact should be minimized through the use of gloves and suitable long-sleeved clothing.

Eye Contact
Eye contact should be prevented through the use of chemical safety glasses, goggles or a face shield.

Inhalation
If dust is generated, it should be controlled by local exhaust ventilation. Where this is not feasible, inhalation can be prevented through the use of a NIOSH-approved particulate filter respirator.

IX. SPILL HANDLING

Make sure all personnel involved in the spill cleanup follow good industrial hygiene practices (refer to Section VIII).

Small spills can be handled routinely. Use adequate ventilation and wear a dust mask to prevent inhalation. Wear suitable protective clothing and eye protection to prevent skin and eye contact. Use the following procedures.

Sweep up the material being careful not to create dust and transfer to an appropriate chemical waste container. Seal container and dispose of in an approved landfill or in such a manner that will not adversely affect the environment. The residue may be flushed with water

IN CASE OF EMERGENCY, CALL, DAY OR NIGHT
(800) 424-9300 (CHEMTREC)

X. CORROSIVITY TO MATERIALS OF CONSTRUCTION

Lined-steel, stainless steel or fiber glass (vinyl ester resin) are the preferred materials of construction for process equipment and storage. Aqueous solutions of this material are corrosive to common metals such as aluminum, copper, most copper containing alloys, galvanized iron and nickel.

XI. STORAGE REQUIREMENTS

Containers should be stored in a cool, dry, well-ventilated area. Exercise due caution to prevent damage to or leakage from the container.

XII. DISPOSAL OF UNUSED MATERIAL

Material that cannot be used or chemically reprocessed should be disposed of in an approved landfill or incinerated by means equipped with appropriate environmental pollution controls.

XIII. DISPOSAL OF CONTAINER

Empty containers may be incinerated by means equipped with appropriate environmental pollution controls or may be discarded with the general trash.