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COMPARISON TESTS ON THE 100-GPM ELECTROKINETIC FUEL DECONTAMINA--ETC(U)
SEP 77 W R WILLIAMS
UNCLASSIFIED MERADCOM-2220

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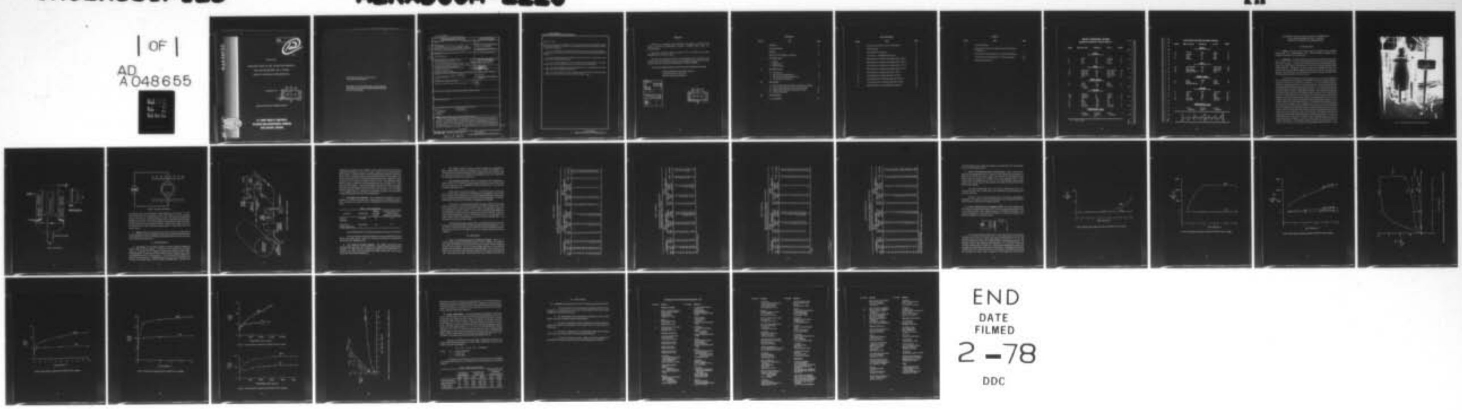

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Report 2220

COMPARISON TESTS ON THE 100-GPM ELECTROKINETIC FUEL DECONTAMINATOR AND A 100-GPM MILITARY STANDARD FILTER/SEPARATOR

September 1977

U.S. ARMY MOBILITY EQUIPMENT
RESEARCH AND DEVELOPMENT COMMAND
FORT BELVOIR, VIRGINIA

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This report covers identical tests performed on the 100-GPM Electrokinetic Fuel Decontaminator and a 100-GPM Military Standard Filter/Separator for the purpose of comparing performances. Performance is based upon the ability to remove emulsified water from fuel. Test fuels were turbine fuel JP-5 and diesel fuel No. 2. Water is injected into the fuel upstream of a centrifugal pump out of the test vessel in concentrations of 0.5, 2, 5, and 10%. The effluent, pressure-drop readings are also taken. The effluent fuel from each test vessel is measured for

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water concentration using a turbidimeter. Tests are performed at ambient temperatures and low temperatures. Results are correlated, and the performances of the two test vessels are compared. Conclusions are as follows:

(a) The Electrokinetic Fuel Decontaminator demonstrates improved, overall efficiency in removing water from turbine fuel and diesel fuel over the currently used Military Standard Filter/Separator.

(b) The Electronkinetic Fuel Decontaminator demonstrates a lower, overall pressure drop than the Military Standard Filter/Separator.

(c) The power consumption of the Electrokinetic Fuel Decontaminator is primarily dependent on the amount of water present and, to a lesser extent, on temperature.

(d) The power consumption for decontaminating diesel fuel is approximately three times as great as that for decontaminating turbine fuel.

(e) The current necessary to remove 1 gallon of water from turbine fuel is approximately 1 ampere; for diesel fuel, the current is approximately 3 amperes.

PREFACE

Authority for conducting research described in this report is contained in The Catalog of Approved Requirement Documents (CARDS) under Project No. 1G762708AH67.

Tests were conducted during December 1976 in the POL Test Facility, MERADCOM, Fort Belvoir, Virginia.

The work was conducted under the overall supervision of T. H. Jefferson, then Chief, Research and Development Group, Fuels Handling Equipment Division, Energy and Water Resources Laboratory, MERADCOM, Fort Belvoir, Virginia.

The following MERADCOM personnel participated in the evaluation program:

William R. Williams, Senior Project Engineer.
Conrad Korzendorfer, Technician.
Richard Crosariol, Test Mechanic.

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METRIC CONVERSION FACTORS

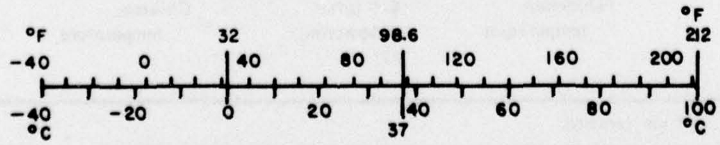
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	metric tons	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	L
pt	pints	0.47	liters	L
qt	quarts	0.95	liters	L
gal	gallons	3.8	liters	L
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

* 1 in = 2.54 cm (exactly).

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10 000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	metric tons (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
L	liters	2.1	pints	pt
L	liters	1.06	quarts	qt
L	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



COMPARISON TESTS ON THE 100-GPM ELECTROKINETIC FUEL DECONTAMINATOR AND A 100-GPM MILITARY STANDARD FILTER/SEPARATOR

I. INTRODUCTION

1. **Subject.** This report covers water-removal tests conducted on the 100-GPM Electrokinetic Fuel Decontaminator and a 100-GPM Military Standard Filter/Separator using turbine fuel and diesel fuel.

2. **Background.** The Electrokinetic Fuel Decontaminator (EFD) was developed under contract with the Atomics International Division of Rockwell International. The EFD is designed to remove water and solid particulates from all military hydrocarbon fuels with improved effectiveness over the present Military Standard Filter/Separator (MSFS). Specifically, the EFD is intended to decontaminate those fuels such as diesel fuel or inhibited turbine fuel which contain surface-active agents (surfactants). The EFD (Figure 1) is a full-scale, developmental prototype produced under the Advanced Development (6.3) level of effort.

The EFD continuously removes suspended water and solid contaminants from hydrocarbon fuels by means of an alternating electric field and depth filtration. The major components of the EFD are as follows: (1) the electrokinetic section including the electrode assemblies; (2) the control section; and (3) the depth filtration section utilizing DOD filter/coalescer elements (Figure 2). The EFD removes suspended water droplets from fuel by subjecting the fuel stream to an alternating electric field generated between concentric, parallel-plate electrodes. Water molecules and droplets are polar and when suspended in a nonpolar fluid in the presence of an electric field will tend to align themselves with the positive end toward the negative plate and the negative end toward the positive plate (Figure 3). By alternating the electric field, the droplets oscillate and collide forming larger droplets and effecting coalescence. Such a process is termed "induced dipole coalescence." The principle can be applied, to some extent, with certain types of solid contaminant, but much of the solid contaminants are removed by the filter/coalescer elements. These elements are the same as elements used in the Military Standard Filter/Separators thereby avoiding the need to stock a separate element. However, the filter elements in the EFD are primarily used for solids removal and not for coalescence. Thus, the "plating out" of surfactants on the fibrous surface has no appreciable, deleterious effects on element performance. The use of the DOD filter/coalescer elements also introduces some redundance into the system and thus increases overall reliability. In case of a power outage, the EFD can be used as a regular filter/separator. The 100-gpm prototype is intended to operate from 115 Vac, 60 Hz; the voltage on the electrodes is approximately 7500 Vac, 60 Hz. Power

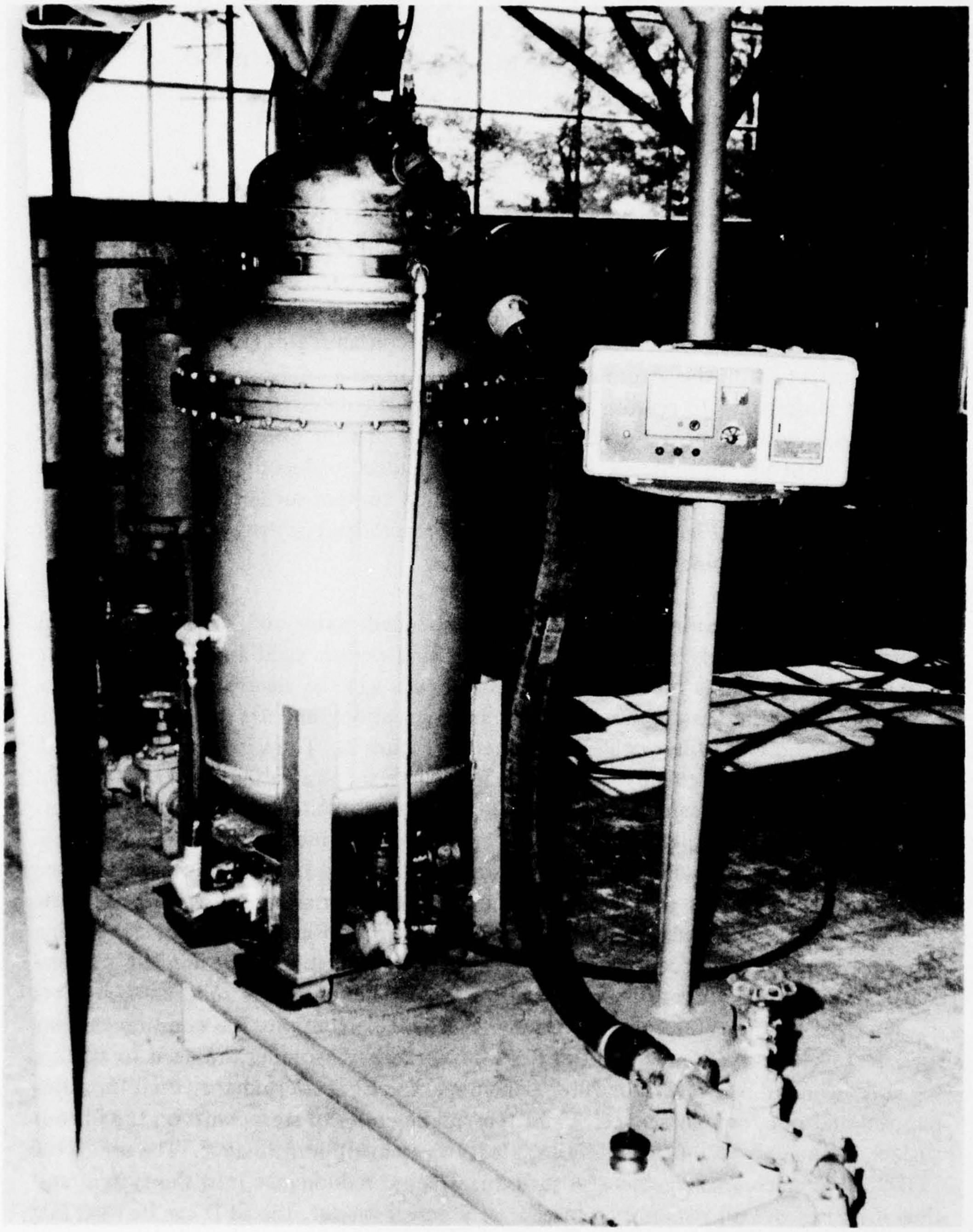


Figure 1. Prototype Electrokinetic Fuel Decontaminator.

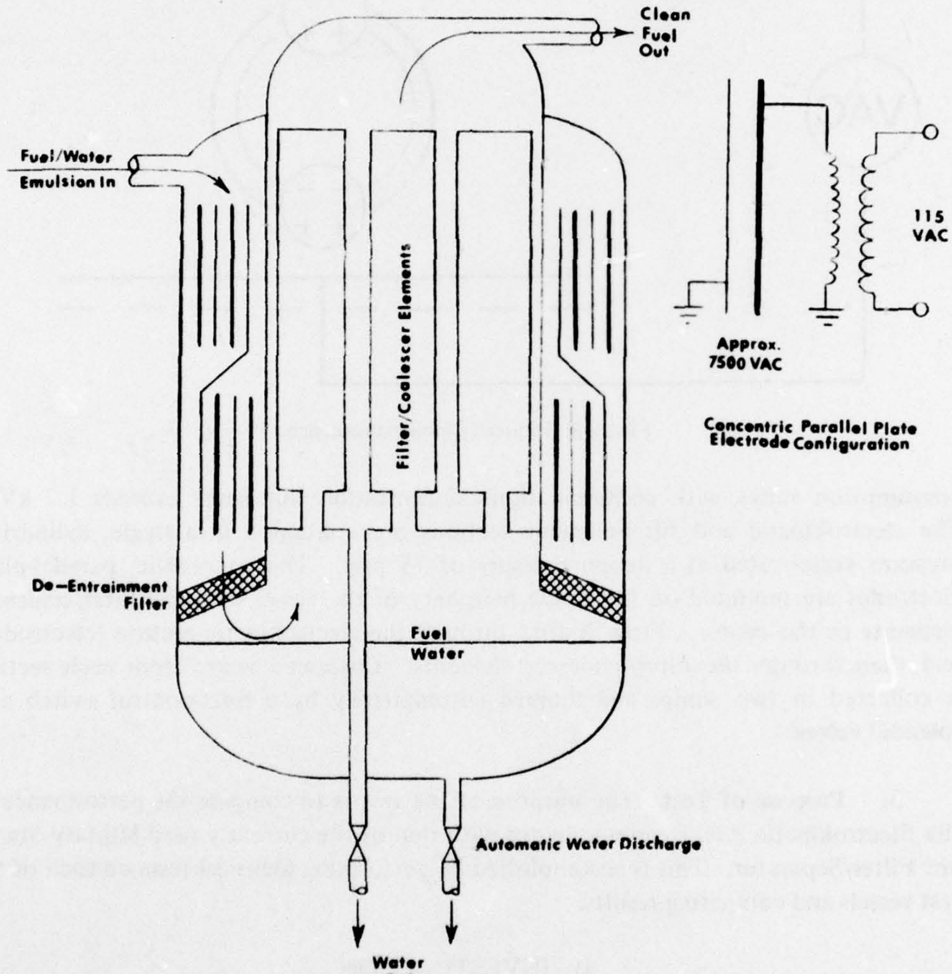


Figure 2. EFD schematic.

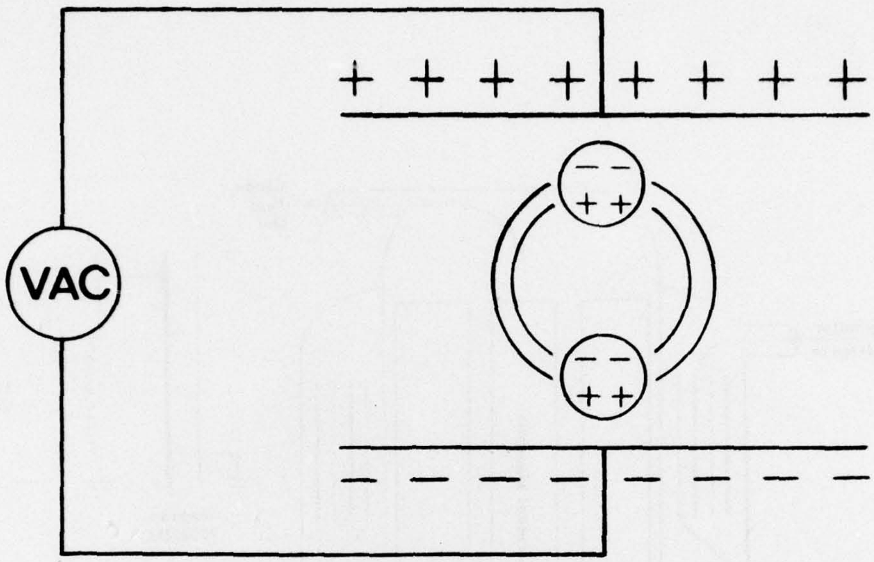


Figure 3. Induced dipole coalescence.

consumption varies with contamination concentration but never exceeds 1.2 kVA. The electrokinetic and filter-element sections are contained in a single, cylindrical pressure vessel rated at a design pressure of 75 psig. The concentric, parallel-plate electrodes are mounted on the inside periphery of the vessel with the filter/coalescer elements in the center. Flow is first through the electrokinetic section (electrodes) and then through the filter/coalescer elements. Coalesced water from each section is collected in two sumps and drained automatically by a float-control switch and solenoid valves.

3. **Purpose of Test.** The purpose of the test is to compare the performance of the Electrokinetic Fuel Decontaminator with that of the currently used Military Standard Filter/Separator. This is accomplished by performing identical tests on each of the test vessels and comparing results.

II. INVESTIGATION

4. **Test Facility.** The test facility consists of a nominal, 100-gpm pumping loop with all necessary auxiliary piping. A schematic of the pumping loop is shown in Figure 4. In general, the test equipment resembles that described in MIL-F-8901, "Filter/Separators, Liquid Fuel and Filter Coalescer Elements, Fluid Pressure: Inspection Requirements and, Test Procedure For." The test vessel (EFD or MSFS) is installed in the loop as shown. A 1,000-gallon feed tank receives the test batches of fuel. The fuel is recirculated using a nominal, 100-gpm centrifugal pump. The flow rate is

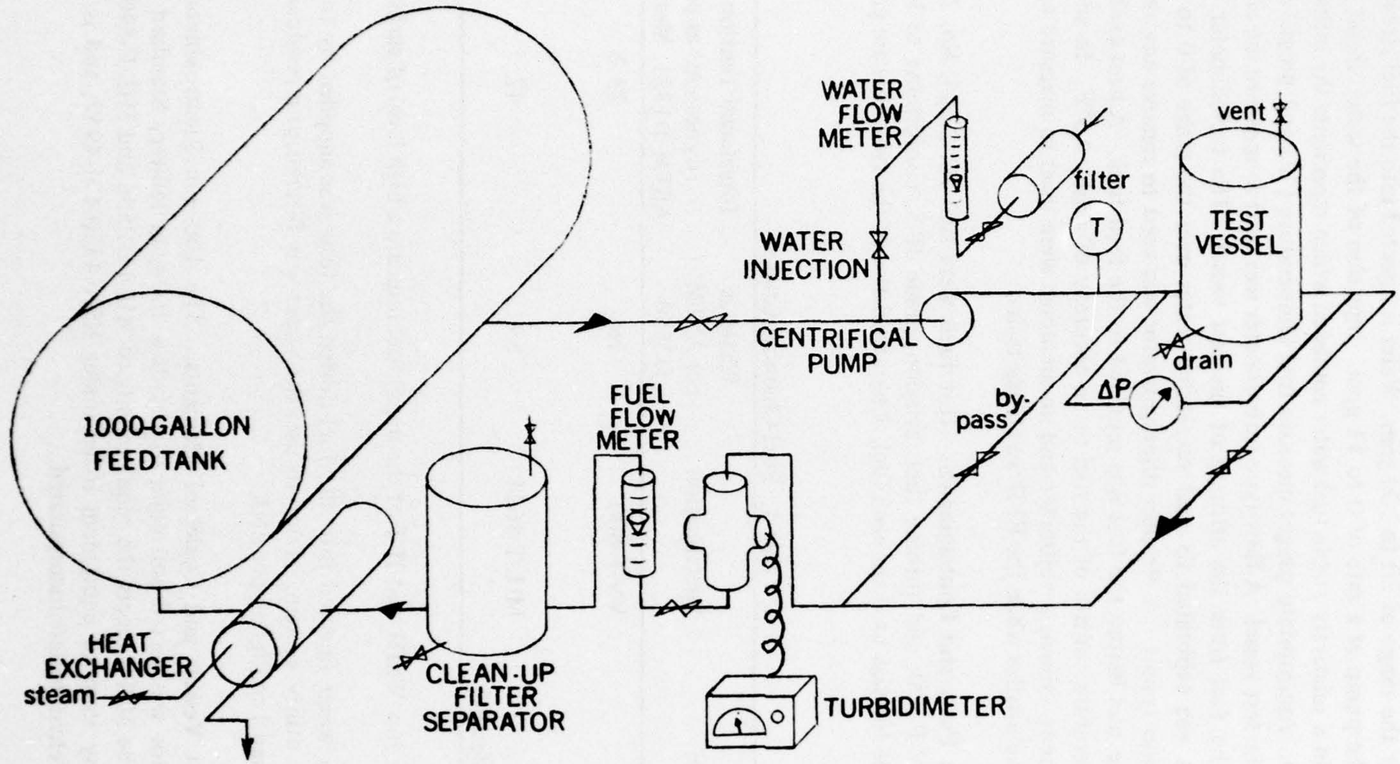


Figure 4. Test facility – 100-gpm pumping loop.

adjustable over the range of 30 to 100 gpm. Water is injected into the fuel stream just upstream of the pump at a rate of 0 to 11 gpm. Injection of the water ahead of the pump results in a relatively stable fuel-water emulsion which represents the influent to the test vessel. Appropriate gauges measure fuel temperature (°F) and pressure drop (psig) across the test vessel. A flow-type turbidimeter was used to measure the amount of water in the fuel from the effluent of the test vessel. The turbidimeter (Keen Model 861 B) was calibrated to read suspended water over the range of 0 to 5,000 parts per million (ppm). A cleanup filter/separator was used to remove any residual water from the fuel before the fuel was returned to the feed tank. A heat exchanger provides temperature control of the fuel to an accuracy of about ±3°F. In addition to the equipment shown, a voltmeter and an ammeter were used to measure applied electrical characteristics when the EFD was being tested.

5. **Test Fuels and Contaminants.** Test fuels were fuel oil, diesel, No. 2, conforming to VV-F-800; and turbine fuel, aviation, grade JP-5, conforming to MIL-T-5624. A single lot was used for each fuel. Characteristics of the two fuels are given in Table 1.

Table 1. Fuel Characteristics

Test Fuel	Specification	WSIM as per ASTM D2550	Interfacial Tension, IFT (dynes/cm) as per ASTM D1331, Method B
Fuel Oil, Diesel No. 2	VV-F-800	16	23.2
Turbine Fuel, Aviation, Grade JP-5	MIL-T-5624	89	42

The low WSIM and IFT of the diesel fuel indicate a high level of surfactants.

The water injected into the fuel during the tests was supplied by the Fort Belvoir water utility system. Prior to use, the water was filtered to a residual-solids level of less than 1 milligram per liter.

6. **Test Vessels and Coalescer Elements.** The 100-gpm Electrokinetic Fuel Decontaminator was tested and compared with a 100-gpm Military Standard Filter/Separator. The MSFS meets the requirements of MIL-F-52556 and MIL-F-8901, is a standard Army item of equipment listed under NSN 4330-491-4957, and is manufactured by Velcon Filters Incorporated.

Five Military Standard coalescer elements meeting the requirements of MIL-F-52308 and MIL-F-8901 were installed in both the EFD and the MSFS. The coalescer elements were manufactured by Keene Corporation and were all from a single lot, 73-010; new elements were installed at the beginning of each test or whenever an unusually high pressure drop was encountered.

7. **Test Procedures and Results**. Prior to the initiation of tests, 1000 gallons of turbine fuel, JP-5, were treated by passage through clay filters to remove most of the gums and surfactants. Four, 1000-gallon batches of diesel fuel, No. 2, were blended to obtain a single, uniform lot.

Three series of tests were performed – one with JP-5 and two with diesel fuel. In each test series, fuel-flow rate, water-injection rate, temperature, and test time were controlled while measurements were made of differential pressure (pressure drop across test vessel) and effluent quality as measured by the turbidimeter. In addition, for the EFD, measurements of the voltage and amperage were also taken.

In test series I, the EFD and the MSFS were each tested with JP-5 under ambient temperatures (~80°F) with fuel-flow rates of 100 to 110 gpm (100 to 110% of rated flow) and water-injection rates of 0.5 to 10% of fuel-flow rates. Test conditions and results are shown in Table 2. In test series II, the EFD and the MSFS were each tested with a separate batch of diesel fuel, No. 2, from the same lot. Testing was under ambient temperatures (~80°F) with fuel-flow rates of 75 to 100 gpm (75 to 100% of rated flow) and water-injection rates of 0.5 to 5% of fuel-flow rates. Test conditions and results are shown in Table 3.

Test series III also used separate batches of diesel fuel from the same lot for testing of the EFD and the MSFS. Testing was under lowered temperatures (~53°F and ~66°F) with fuel-flow rates of 30 to 75 gpm (30 to 75% of rated flow) and water-injection rates of 0.5 to 5% of fuel-flow rates. Test conditions and results are shown in Table 4.

III. DISCUSSION

8. **Effect of Water-Injection Rates on Effluent Fuel Quality**. Figures 5, 6, 7, and 8 represent plots of water-injection rates (in % water) vs effluent fuel quality (in ppm water) for the MSFS and the EFD in test series I, II, and III. This is an indication of water-removal efficiency. As can be seen, the higher the flow rate, the greater the differences in performance between the EFD and the MSFS. The water level in the effluent from the EFD remains relatively constant over the range of water-injection rates. This indicates that water is removed from the EFD at about the same rate that

Table 2. Test Series I

Test Fuel: Turbine Fuel, Aviation, Grade JP-5; Ambient Temperatures
Filter/Coalescer Element: Keene Lot 73-010

Test Conditions			Test: Ia Test Item: 100-gpm MSFS			Test: Ib Test Item: 100-gpm EFD				
Time (min)	Total Flow (gpm)	Water Injection (%)	Fuel Temp (°F)	Differential Pressure (psig)	Turbidimeter Reading (ppm H_2O)	Fuel Temp (°F)	Differential Pressure (psig)	Turbidimeter Reading (ppm H_2O)	Voltage	Amperage
0	100	0	81	2.4	–	79	3.5	–	76	0.90
10	100	0.5	81	4.6	0	82	4.2	0	77	1.32
20	100	0.5	82	5.5	0	80	4.5	0	77	1.45
30	100	0.5	82	6.0	0	81	4.8	0	77	1.50
40	100	2.0	82	7.2	0.1	81	4.9	0	77	2.28
50	100	2.0	82	7.9	0.1	80	5.0	0	77	2.30
60	100	2.0	81	8.2	0.1	80	5.1	0	77	2.35
70	100	5.0	79	9.5	0.3	78	5.5	0	77	3.00
80	100	5.0	80	9.7	0.3	79	5.5	0	77	3.10
90	100	5.0	80	10.0	0.4	80	5.5	0	77	3.20
100	100	10.0	78	10.5	13.0	78	5.0	0	77	3.60
110	100	10.0	78	11.0	12.0	78	5.0	0	77	3.80
120	100	10.0	78	11.5	12.0	79	5.2	0	77	3.85
130	110	10.0	78	13.0	15.0	78	6.2	0	77	4.05
140	110	10.0	79	13.5	15.0	78	6.1	0	77	4.15
150	110	10.0	79	13.5	16.0	–	–	–	–	–

Table 3. Test Series II

Test Fuel: Fuel Oil, Diesel No. 2; Ambient Temperatures
Filter/Coalescer Element: Keene Lot 73-010

Test Conditions			Test: Ia Test Item: 100-gpm MSFS			Test: Ib Test Item: 100-gpm EFD				
Time (min)	Total Flow (gpm)	Water Injection (%)	Fuel Temp (°F)	Differential Pressure (psig)	Turbidimeter Reading (ppm H_2O)	Fuel Temp (°F)	Differential Pressure (psig)	Turbidimeter Reading (ppm H_2O)	Voltage	Amperage
0	75	0	82	5.4	–	–	–	–	0	0
5	75	5.0	78	15.0	233.9	81	7.0	1.8	108	9.60
10	75	5.0	78	14.5	43.9	81	7.1	2.3	108	9.60
15	100	0.5	83	16.7	77.9	82	9.7	5.5	108	3.05
20	100	0.5	82	16.9	243.9	82	10.0	8.0	109	3.05
25	100	2.0	80	18.0	2493.9	81	10.2	10.5	108	6.15
30	100	2.0	80	18.4	2643.9	81	10.5	14.0	108	6.15
35	100	5.0	77	19.5	4993.9	80	10.8	98.4	108	10.40
40	100	5.0	77	19.8	2243.9	80	11.2	49.0	108	10.40
45	100	2.0	79	18.7	1993.9	81	11.0	10.0	.08	6.35
50	100	2.0	80	18.5	1943.9	80	11.0	1784.0*	0	0
55	100	2.0	80	18.8	1793.9	80	11.2	18.0	110	6.50

* Power shut off for this reading only.

Table 4. Test Series III

Test Fuel: Fuel Oil, Diesel No. 2 (Single Lot); Low Temperatures
Filter/Coalescer Element: Keene Lot 73-010

Test Conditions			Test IIIa Test Item: 100-gpm MSFS			Test IIIb Test Item: 100-gpm EFD				
Time (min)	Total Flow (gpm)	Water Injection (%)	Fuel Temp (°F)	Differential Pressure (psig)	Turbidimeter Reading (ppm H_2O)	Fuel Temp (°F)	Differential Pressure (psig)	Turbidimeter Reading (ppm H_2O)	Voltage	Amperage
0	30	0	52	5	–	52	1.5	–	0	0
5	30	0.5	53	7.8	87.7	53	1.5	0	110	2.90
10	30	0.5	53	9.5	69.7	54	1.8	0	110	2.90
15	30	2.0	53	12.0	126.7	53	2.0	0	110	5.65
20	30	2.0	53	13.7	131.7	52	2.1	0	110	5.65
25	30	5.0	52	15.4	241.7	52	2.2	0	110	8.60
30	30	5.0	52	17.0	306.7	51	2.2	0	110	8.60
35	45	0.5	53	29.0	491.7	53	4.0	0	110	3.20
40	45	0.5	53	32.0	551.7	53	4.3	0	110	3.10
45	45	2.0	53	39.0	1391.7	52	4.4	0	110	6.30
50	45	2.0	53	43.0	1441.7	52	4.6	0	110	6.30
55	45	5.0	52	51.0	2291.7	52	5.1	0	110	9.40
60	45	5.0	53	53.0	2441.7	52	5.7	0	110	9.50
65	60	0.5	53	72.0	2491.7	52	8.1	0	110	3.00
70	60	0.5	53	78.0	3991.7	53	8.7	0	110	3.10
75	60	2.0	–	–*	–*	53	9.0	0.2	110	6.80
80	60	2.0	–	–*	–*	53	9.2	0.5	110	6.80

* Offscale.

Table 4. Test Series III (Cont'd)

Test Fuel: Fuel Oil, Diesel No. 2 (Single Lot); Low Temperatures
Filter/Coalescer Element: Keene Lot 73-010

Test Conditions			Test IIIa Test Item: 100-gpm MSFS			Test IIIb Test Item: 100-gpm EFD				
Time (min)	Total Flow (gpm)	Water Injection (%)	Fuel Temp (°F)	Differential Pressure (psig)	Turbidimeter Reading (ppm H_2O)	Fuel Temp (°F)	Differential Pressure (psig)	Turbidimeter Reading (ppm H_2O)	Voltage	Amperage
0	45	0	66	5.0	–**	64	6.7	–	0	0
5	45	0.5	66	4.0	5.9	65	7.0	0.5	107	2.85
10	45	0.5	66	4.8	0	65	7.2	0.7	107	2.85
15	45	2.0	66	5.8	0	66	7.3	0.7	107	5.45
20	45	2.0	66	6.0	0	66	7.3	0.7	107	5.50
25	45	5.0	65	6.9	1.3	64	7.7	1.1	106	8.30
30	45	5.0	64	7.1	1.5	64	8.0	1.4	106	8.30
35	60	0.5	66	8.2	0.9	65	10.7	4.1	107	3.00
40	60	0.5	65	8.5	1.4	65	10.3	4.0	107	3.15
45	60	2.0	65	9.0	6.9	65	10.3	4.1	107	6.05
50	60	2.0	65	9.0	8.4	65	10.7	4.9	107	6.00
55	60	5.0	64	9.8	17.9	64	10.1	8.1	107	9.20
60	60	5.0	65	10.0	23.9	63	10.8	11.1	107	9.20
65	75	0.5	66	10.4	23.9	65	12.8	14.0	108	3.05
70	75	0.5	66	10.4	33.9	65	13.0	15.1	108	3.00
75	75	2.0	66	10.9	83.9	65	12.9	14.1	108	6.05
80	75	2.0	66	11.0	93.9	66	12.8	14.1	108	5.95
85	75	5.0	65	11.5	88.9	65	12.9	33.1	109	9.60
90	75	5.0	65	11.5	93.9	66	12.9	38.1	109	9.60

** New filter/coalescer elements installed.

NOTE: Pressure-drop data on the MSFS is not considered valid for this test.

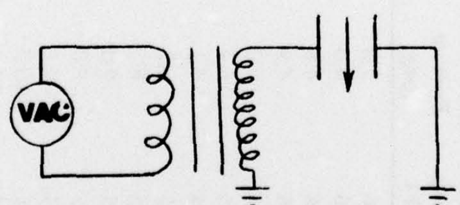
it is being injected, and no appreciable buildup is occurring either in the electrokinetic section or in the filtration section.

9. Effect of Water-Injection Rates on Pressure Drop. Figures 9 and 10 represent plots of water-injection rates (in % water) vs total pressure drop (in psig) for the MSFS and the EFD in test series I and II. (Test series III is not included here; the pressure drops encountered in the MSFS were of such magnitude that the filter elements had to be charged after the 53°F run.) The EFD maintains a nearly constant pressure drop over the range of water-injection rates while the pressure drop of the MSFS increases slightly.

The lower, pressure-drop level in the EFD is evidence that most of the coalescence by the EFD is taking place in the electrokinetic section and not in the coalescence elements.

Figures 11 and 12 represent pressure drop as a function of total gallonage throughput. The nearly flat curve at the EFD indicates that no appreciable buildup of solids or resins is occurring on the filtration elements.

10. Factors Affecting Power Consumption of EFD. The current readings on the EFD appear to be primarily dependent on the amount of water injected and the nature of the dielectric (fuel) with a minimum amount of temperature dependence. The current is independent of the fuel-flow rate (Figure 13). This is to be expected as the EFD acts essentially as a capacitative circuit.



The current passing through such a circuit will depend on the dielectric constant (ϵ) of the fluid. The fluid, in this case, is a suspension of water in fuel. The dielectric constant of water (~80) is high compared to that of fuel (~2); thus, the amount of water present will be the controlling factor in determining capacitance. The dielectric constant varies somewhat with temperature ($\epsilon \propto$ ‡), and this is reflected in the three different plots for diesel fuel. Diesel fuel decontamination requires substantially more current than turbine fuel decontamination. The differences in dielectric constant of the two fuels are too small to account for this. This difference in current may represent the extra energy necessary to effect coalescence in diesel fuel.

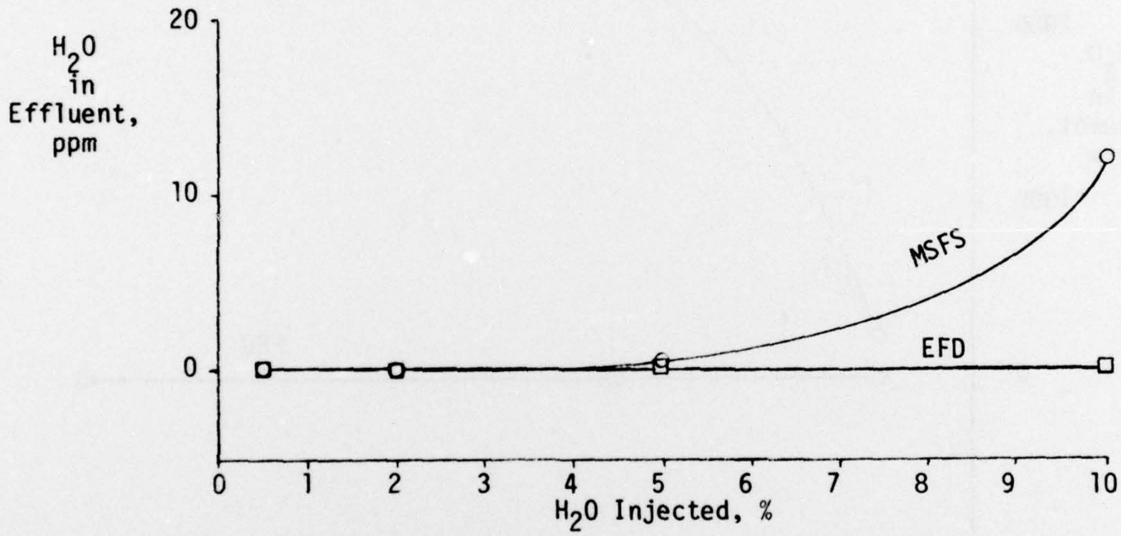


Figure 5. Water injection vs effluent fuel quality; JP-5 @ 80° F (30-min. readings).

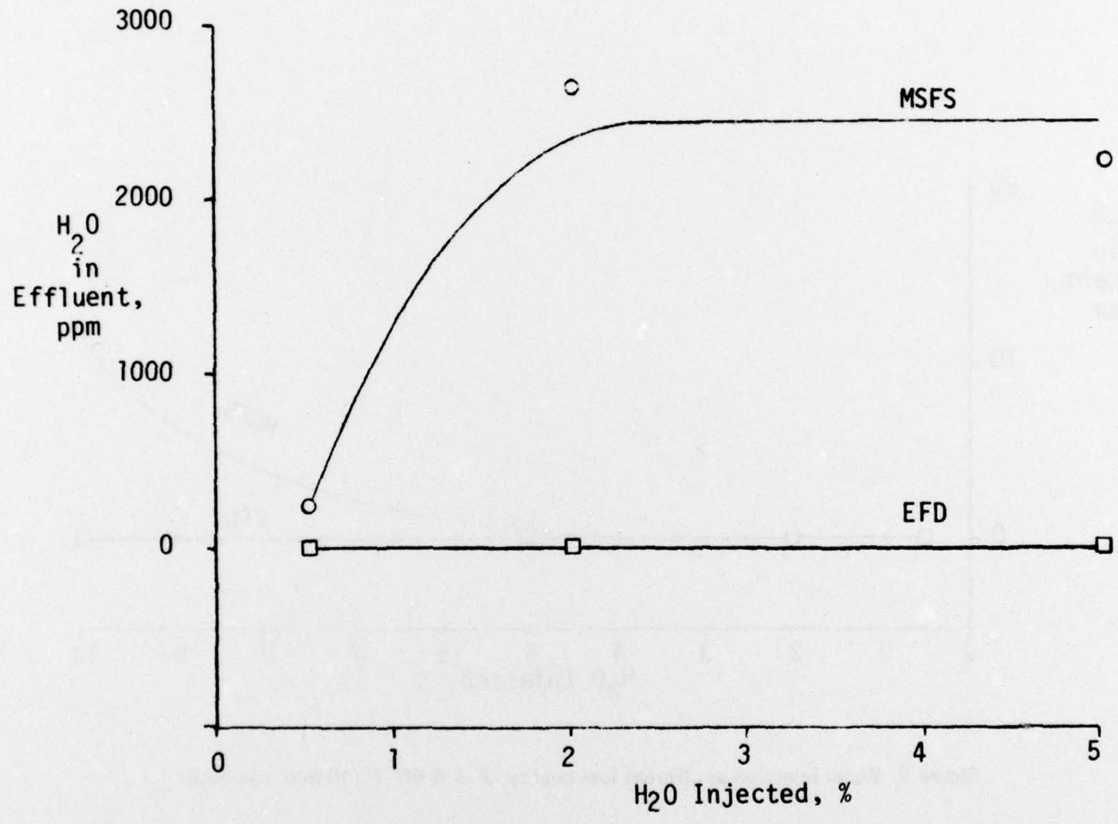


Figure 6. Water injection vs effluent fuel quality; DF-2 @ 80° F (10-min. readings).

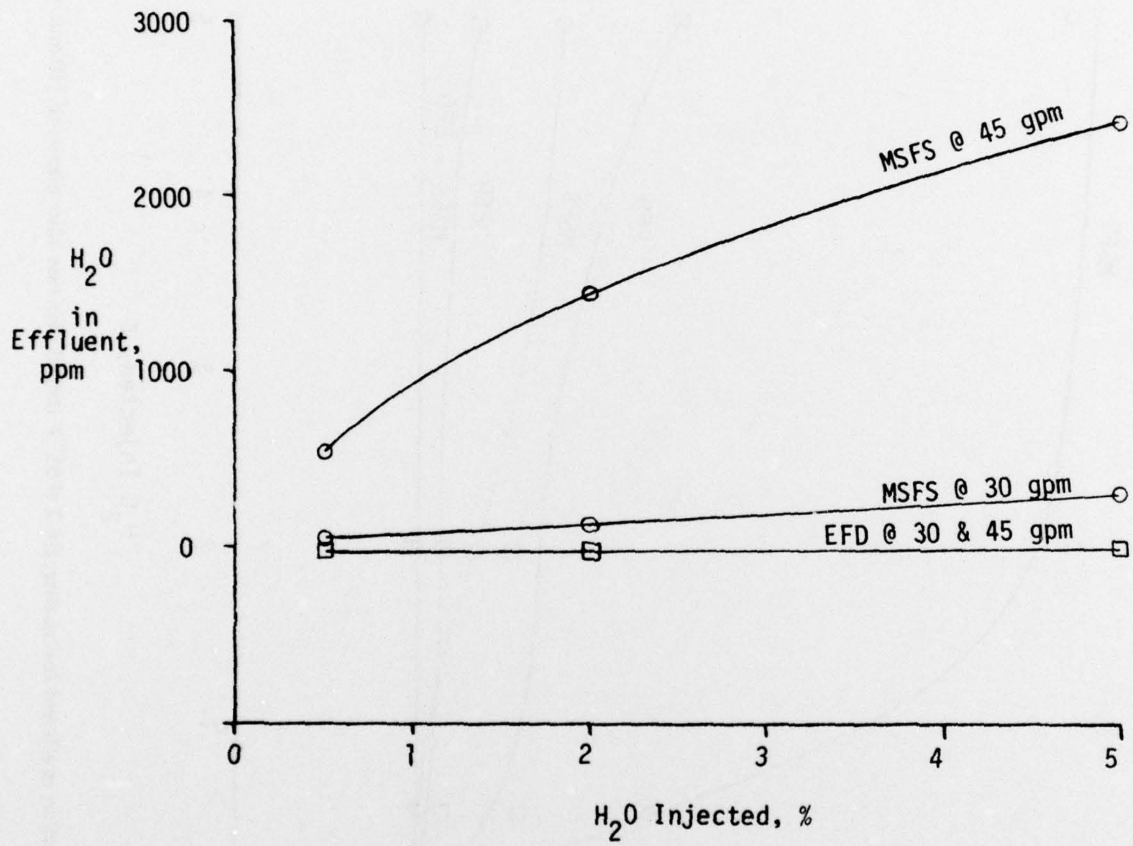


Figure 7. Water injection vs effluent fuel quality; DF-2 @ 53° F (10-min. readings).

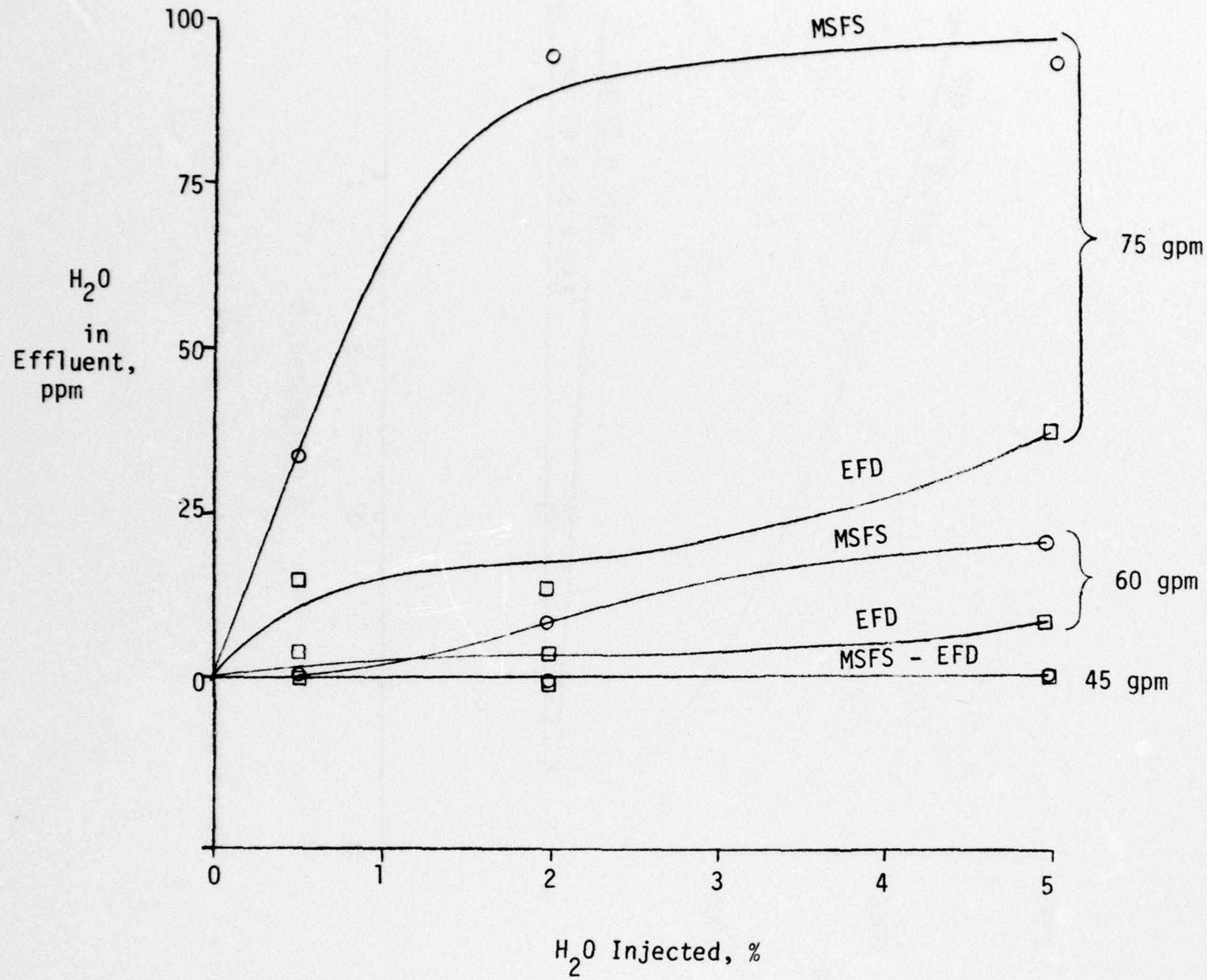


Figure 8. Water injection vs effluent fuel quality; DF-2 @ 65° F (MSFS with new filter elements) (10-min. readings).

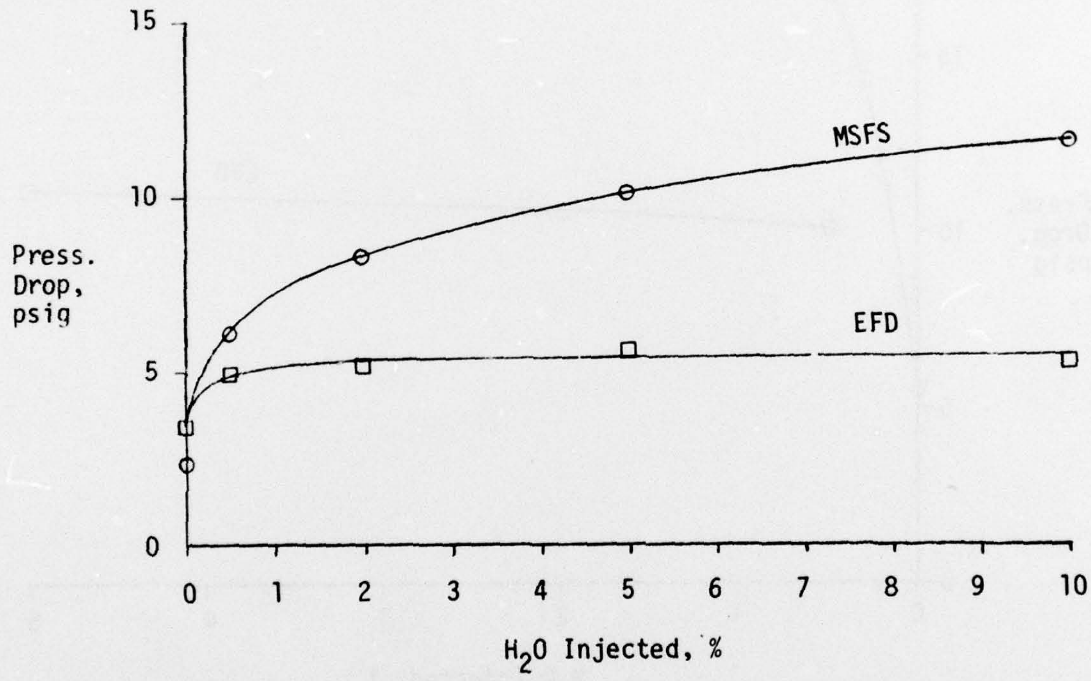


Figure 9. Water injection vs pressure drop; JP-5 @ 80° F (30-min. readings).

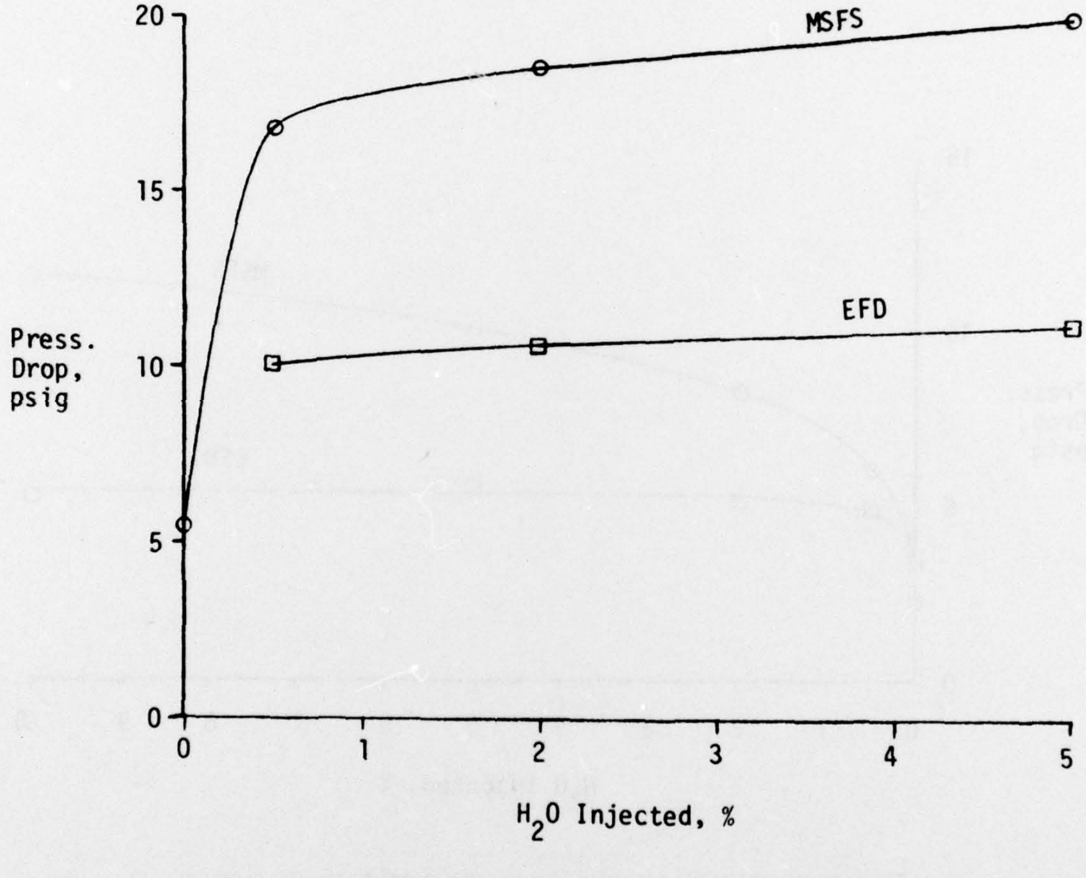


Figure 10. Water injection vs pressure drop; DF-2 @ 80° F (10-min. readings).

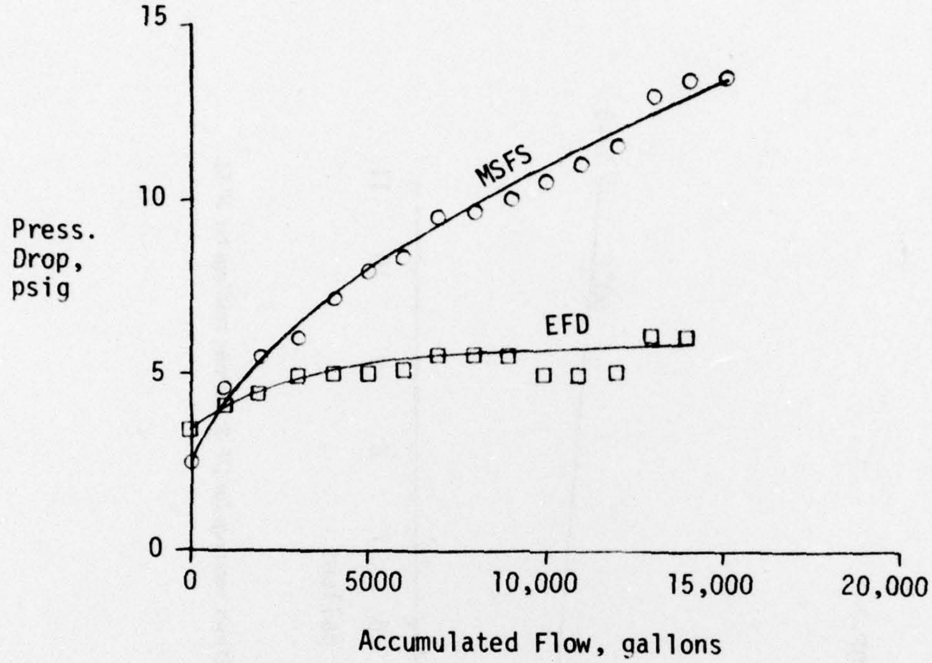


Figure 11. Accumulative flow vs pressure drop; JP-5 @ 80° F (30-min. readings).

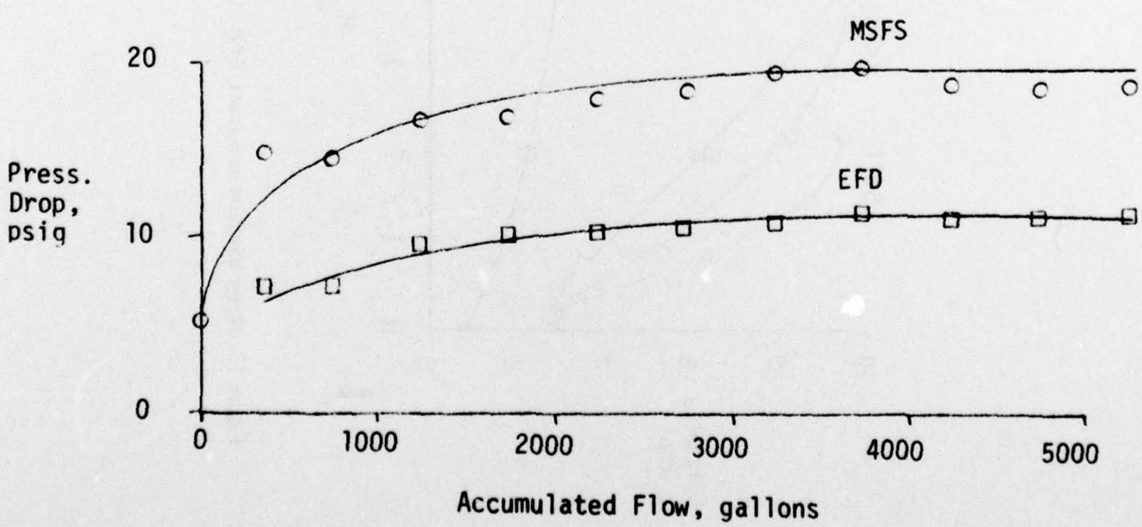


Figure 12. Accumulative flow vs pressure drop; DF-2 @ 80° F (10-min. readings).

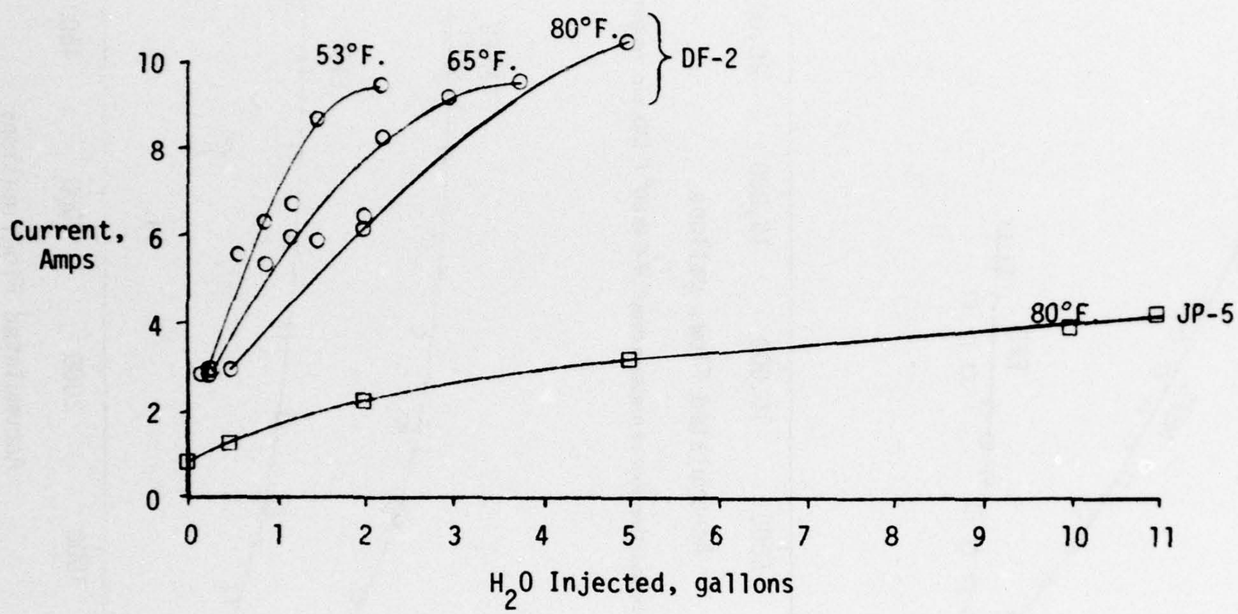


Figure 13. Water injection vs current, EFD; DF-2 and JP-5 (10-min. readings for DF-2; 30-min. readings for JP-5).

Suspended water droplets in diesel fuel are surrounded by a micro-molecular layer of surfactants presenting a hydrophilic/lipophilic barrier. Coalescence can only take place by breaking this barrier. The energy necessary to accomplish this and the fact that the droplets are smaller in size and hence more numerous may account for the higher current consumed in diesel fuel coalescence.

11. **Energy Considerations.** The most significant disadvantage of the EFD is its use of electric energy. The amount of electricity consumed will depend on the type of fuel and on the amount of water removed. Turbine fuel requires about 1 ampere per gallon of water; diesel fuel, about 3 amperes per gallon. The circuitry of the EFD is essentially reactive and is, therefore, expected to possess a relatively low power factor. Assuming a power factor of 0.5 with 115 volts; the total amount of electric power to remove 1 gallon of water is 1 x 115 x 0.5 = 57.5 W or 0.058 kW for turbine fuel and 3 x 115 x 0.5 = 172 W or 0.172 kW for diesel fuel. Thus, to decontaminate 10,000 gallons of diesel fuel contaminated with 2 percent water at 100 gpm (200 gallons of water for 100 minutes or 1.67 hr), the total energy will be 200 x 1.67 x .172 = 57.4 kWh. At an average cost of $0.28 per kWh, this amounts to $1.61.

However, the EFD also saves some energy. Mechanical energy losses are realized when fuel flows through the test vessel. Most of this is due to pressure drop. Work or energy loss is expressed as:

$$W = \int v\,dp \quad \text{or } v\,(p_2 - p_1) \quad \text{(for liquids)}$$

where:
- W = work or energy (kJ)
- v = volume (m^3)
- p = pressure (kPa)

To compute the work saved by the use of the EFD over that of the MSFS, the pressure-drop differences are tabulated and the work differences are calculated (Table 5).

Table 5. Work Saved by the EFD

	Avg Pressure Drop Difference		Work Difference per m^3 Fuel		Work Difference per 10,000 gals ($37.85\ m^3$) of Fuel	
	(psig)	(kPa)	(kJ)	(kWh)	(kJ)	(kWh)
Avg of Test Series I	3.97	22.35	27.35	7.60×10^{-3}	1035	0.288
Avg of Test Series II	7.75	53.40	53.40	14.83×10^{-3}	2021	0.561
2% H_2O in JP-5	2.77	19.09	19.09	5.30×10^{-3}	723	0.201
2% H_2O in DF-2	7.60	52.36	52.36	14.54×10^{-3}	1982	0.550

IV. CONCLUSIONS

12. **Conclusions.** Based upon the test data, the following conclusions are drawn:

a. The Electrokinetic Fuel Decontaminator demonstrates improved, overall efficiency in removing water from turbine fuel and diesel fuel over the currently used Military Standard Filter/Separator.

b. The Electrokinetic Fuel Decontaminator demonstrates a lower, overall pressure drop than the Military Standard Filter/Separator.

c. The power consumption of the Electrokinetic Fuel Decontaminator is primarily dependent on the amount of water present and, to a lesser extent, on temperature.

d. The power consumption for decontaminating diesel fuel is approximately three times as great as that for decontaminating turbine fuel.

e. The current necessary to remove 1 gallon of water from turbine fuel is approximately 1 ampere; for diesel fuel, the current is approximately 3 amperes.

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