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DEVELOPMENT OF AN ADVANCED JP-8 FUEL

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This technical report has been reviewed and is approved for publication.

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Techncial effort was directed at increasing the design limit of current JP-8 fuel from 325F (163C) to 425F (218C) at the fuel nozzle. The objective was to accomplish this near-term thermal stability goal solely through the use of a fuel soluble additive package. JP-Thermally stable fuel was considered the thermal stability target since it has the high-temperature properties sought from the significantly more economical JP-8 + 100 formulation. The additives were evaluated in an additive-free Jet A considered typical of fuel most likely encountered in the field. DuPont JFA-5, currently the only accepted thermal stability improving additive, was considered state of the art and used as a bench mark. Additive manufacturers were surveyed and solicited for candidate additives that had potential for improving fuel thermal oxidative stability. Test methods were developed and/or refined for use in screening additives. Using the Hot Liquid Process Simulator (HLPS) in conjunction with a LECO Carbon Determinator, 152 additives were screened. Additive performance was ranked based on surface carbon and differential pressure. Additional screening was performed using the Isothermal Corrosion Oxidation Test (ICOT). The additives screened included oxygen, sulfur, and nitrogen-type antioxidants; dispersants; detergents; metal deactivators; antifoulants; and proprietary thermal stability improvers. Twenty-seven experimental blends comprised of various additive combinations were tested. Five baseline fuels were evaluated. These fuels included POSF 2827 Jet A reference fuel, POSF 2799 JP-Thermally Stable, POSF 2747 Super K-1 kerosene, POSF 2926 Shell Oil Jet A, and POSF 2928 Exxon Jet A with 15% hydrocracked stock. POSF 2827 represented a typical Jet A and was the primary reference fuel in which the additive candidates were blended and evaluated. A number of special investigations were also performed. A detergent/dispersant was identified that approached the thermal stability target. Future work will be directed at formulating and optimizing a package comprised of a detergent/dispersant, an antioxidant, and a metal deactivator.

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PREFACE AND ACKNOWLEDGMENTS

This final report describes the technical effort conducted under Air Force Contract No. F33615-90-C-2051, entitled "Development of An Advanced JP-8 Fuel." The technical effort described herein was conducted over a period from August 1990 through January 1993. The research conducted under this contract was administered under the direction of Mr. Steven Anderson, WL/POSF Project Scientist, and Tedd Biddle, P&W Program Manager.

The research conducted under this program was the product of many contributors. Among those who provided guidance and practical experience in pursuit of the program objectives were Steven Anderson, Mel Roquemore, William Harrison, Timothy Edwards, and Robert Morris of WL/POSF. The P&W team which acted as a liaison with the additive manufacturers, compiled the candidate additive inventory, performed screening tests, test method development, and considered the affects of a high-temperature fuel on fuel system components included Tedd Biddle, William Edwards, Earl Hamilton, Toni Massar, Mike Polito, and Richard Sullivan of the P&W Fuels and Lubricants Laboratory; Matt Eder of the F119 Controls Group; and Charlie Graves of the F119 Combustor and Augmentor Group; and Andy Brankovic of the CFD Modeling Group.

Contributors from the University of Dayton Research Institute included Robert Kauffman, Vish Katta, Steven Zabarnic, and Shawn Heneghan. In addition, technical support was provided by Ted Williams, Ed Bins, and Chuck Martel of Systems Research laboratory. Support directed at implementing the Quartz Crystal Microbalance at P&W for monitoring fuel deposition rates in real time was provided by Elmer Klavetter, Steven Martin, and Leonard Casaus of Sandia National Laboratory. The aforementioned organizations and personnel were instrumental in the successful completion of this program. The diverse mix of disciplines, expertise, and experience provided considerable insight into reaction mechanisms and kinetics of deposit formation, CFD modeling, test method development, additive chemistry, and implementation of experimental approaches for determining the propensity of fuels and additives to oxidize and to form deposits and bulk fuel insolubles in static and flowing systems.

1.0 SUMMARY

Technical effort was directed at increasing the design limit of current JP-8 fuel from 325°F (163°C) to 425°F (218°C) at the fuel nozzle. The objective was to accomplish this near-term thermal stability goal solely through the use of a fuel soluble additive package. JP-Thermally stable fuel was considered the thermal stability target since it has the high-temperature properties sought from the significantly more economical JP-8 + 100 formulation. The additives were evaluated in an additive-free Jet A considered typical of fuel most likely to be encountered in the field. DuPont JFA-5, currently the only accepted thermally stability improving additive, was considered state of the art and used as a bench mark.

Additive manufacturers were surveyed and solicited for candidate additives that had potential for improving fuel thermal oxidative stability. Test methods were developed and/or refined for use in screening additives. Using the Hot Liquid Process Simulator (HLPS) in conjunction with a LECO Carbon Determinator, 152 additives were screened. Additive performance was ranked based on surface carbon and differential pressure. Additional screening was performed using the Isothermal Corrosion Oxidation Test (ICOT).

Additives screened included oxygen, sulfur, and nitrogen-type antioxidants; dispersants; detergents; metal deactivators; antifoulants; and proprietary thermal stability improvers. Twenty-seven experimental blends comprised of various additive combinations were tested. Five baseline fuels were evaluated. These fuels included POSF 2827 Jet A reference fuel, POSF 2799 JP-Thermally Stable, POSF 2747 Super K-1 kerosene, POSF 2926 Shell Oil Jet A, and POSF 2928 Exxon Jet A with 15% hydrocracked stock. POSF 2827 represented a typical Jet A and was the primary reference fuel in which the additive candidates were blended and evaluated. A number of special investigations were also performed. A detergent/dispersant was identified that approached the thermal stability target.

2.0 INTRODUCTION

Fuel thermal stability has been recognized as a critical limiting factor in the design of advanced engines. Increased heat loads resulting from increases in lubricant and hydraulic fluid operating temperatures and extensive airframe electronics will rely on the cooling capabilities of the fuel. To accommodate these heat loads, engine hardware designers and fuel developers are confronted with developing coke resistant hardware in combination with fuels with greater cooling capacities. Unless more thermally stable fuels are developed, the benefits of programs such as the Integrated High Performance Turbine Engine Technology (IHPTET) initiative will be partially offset by the need for larger recirculating systems to maintain fuel temperatures below their thermal stability limits. Development of high temperature fuels will rely on the availability of precise, analytical tools for characterizing the thermal stability properties of jet fuels and to accurately model the thermal deposition process.

This program focused on the development and demonstration of innovative laboratory-scale techniques, and use of these techniques in the formulation of a near-term advanced JP-8 fuel. The program was directed specifically at development of an advanced JP-8 fuel to meet or exceed near-term fuel thermal oxidative stability goals. Near-term high temperature stability requirements have been identified by Wright Laboratory (WL) as an increase in fuel temperature at the nozzle from 325° to 425°F (163 to 218°C). This has been described in fuel development terms as JP-8 + 100°F fuel. As a prerequisite to JP-8 + 100°F development, unique and innovative laboratory techniques are required for use in screening, evaluation, and study of candidate fuel/additive formulations. The analytical methodologies developed under this program focused on quantification of fuel deposits and compositional changes of candidate fuel formulations under thermal stress.

Program goals were pursued under four interrelated tasks:

- Task I - Development of Techniques For Screening and Evaluating Additives
- Task II - Procurement and Blending of Fuel/Additive Formulations
- Task III - Screening and Evaluation of Candidate Additives
- Task IV - Characterization of Formu-lations Meeting JP-8 + 100°F Criteria

3.0 RESULTS AND DISCUSSION

Task I - Development of Techniques For Screening and Evaluating Additives

Task I was directed at development, refinement and implementation of new test methods for screening candidate additive formulations and, ultimately, for characterizing the temperature capabilities of an advanced JP-8 fuel meeting the requirements of JP-8 + 100 °F.

Four test methods were developed and evaluated, or existing methods refined, for use in screening additives and baseline fuels. These included the Microthermal Precipitation Test (MTP), Fuel Reactor Test, Hot Liquid Process Simulator (HLPS), and Isothermal Corrosion Oxidation Test (ICOT).

- *Microthermal Precipitation Test*

The impetus for this development effort was the need for a screening test that could discriminate between fuels of varying propensity to produce thermally induced insoluble particulate material in the bulk fuel. The Microthermal Precipitation (MTP) test thermally stresses a 500-milliliter (mL) fuel sample at 300°F (149°C) for three hours. Fuel pretreatment includes a 6-minute air sparge. A constant oxygen supply to the fuel is maintained by way of 200 psig air pressurization. The fuel is continuously stirred throughout the test. Test temperature is based on fuel temperature as opposed to skin temperature.

At the conclusion of the test, three 50-mL and three 100-mL aliquots of the fuel are filtered through an in-line 25-millimeter (mm) Gelman glass filter having a 1-micron nominal pore size. Particulate material suspended in each aliquot is captured on a Gelman glass filter and quantified via carbon burnoff using a LECO RC-412 Carbon Determinator. Results are reported as micrograms of carbon per square centimeter ($\mu g/cm^2$).

Test Set Up

The MTP test is a stand-alone system which incorporates a JFTOT fuel reservoir; an aluminum heating mantel; controlling thermocouple; temperature controller; sampling, bypass and purging valves; and a sampling port with an in-line filter for filtering and collecting the sample. A detailed description of the equipment setup is presented in the following paragraphs.

System Pressurization

The fuel reservoir is pressurized with compressed air. Both a pressure relief and an overpressure safety valve are positioned at the top of the reservoir. The overpressure valve was added for safety in case of sudden pressure spikes due to regulator failure or auto ignition. In addition, a shutoff valve isolates the regulator and gauges from the pressurized fuel reservoir during testing. This safeguards against regulator damage in the event of autoignition. A condensing coil is located between the reservoir and pressure gauge to keep condensing vapors from damaging the gauge mechanism.

Heating And Temperature Control

An aluminum heating mantel and temperature controller unit was custom fabricated by InterAv, Inc. The InterAv power supply and enclosure uses an Omega Series 4000A proportional controller. The accuracy of this controller is +/- 0.5% full scale and has a 1°F resolution. To improve temperature stability and reduce heat loss, a zirconium (Zr) wool jacket is placed around the heating mantel.

A temperature controlling thermocouple, inserted through the top of the reservoir cover then lowered, mid-point into sample, is used to control fuel temperature. A calibrated type K chromel/alumel thermocouple is used. A stir plate and stir bar is used to ensure uniform temperature throughout the sample.

Filtering and Collection of Sample

A sample collection port is located at the bottom of the fuel reservoir. Sampling is controlled by two valves. A stainless steel, three-way valve directs the sample through a vernier flow control valve to the filter holder, through the Gelman glass filter, and into a graduated cylinder. Placed in the alternate position, the three-way valve reroutes the sample through a stainless steel tube into a collection beaker. In this second valve position, a nonfiltered sample can be obtained or the reservoir drained.

Filtering is accomplished using a 25-mm Gelman borosilicate glass microfiber filter. The Gelman filters used are type A/E containing no organic binders and are autoclavable. The filters are rated at 1022°F (550°C) and have a 1-micron nominal pore size. Lot numbers are maintained for each analysis. The Gelman glass filter is housed in a Millipore micro-syringe 25-mm filter holder which has been modified with a Swagelok fitting. The filter holder is 304 stainless steel. Filtering rate is governed via the vernier valve which is located downstream of the filter holder. In addition, a vernier valve is positioned in line with a vacuum pump to ensure a constant, uniform vacuum rate during the hexane rinse of each filter.

Results

Preliminary test results showed that the MTP had the ability to discriminate between fuels and additives of varying propensity to form bulk fuel insolubles. Appendix B presents a ranking of additives based on the MTP test as well as a master list of all replicate runs performed. The MTP test was ultimately replaced by the Fuel Reactor test due to a requirement to accelerate additive screening. The Fuel Reactor Test is described in the following section.

• *Fuel Reactor Test*

The Fuel Reactor Test was developed to be less labor intensive than the MTP test and permit testing up to four additives simultaneously. Test conditions are similar to those established for the larger-scale MTP test:

√ *Fuel preparation:* prefiltered through a 10μ-Millipore filter; 6-minute sparge
√ *Sample size:* 60 milliliter (mL)
√ *Reactor vessel:* 75-mL Pyrex glass test tube inserted in a 9 inch X $1^1/_4$ inch O.D. stainless steel bomb
√ *Thermal stressing:* four-port COS aluminum block heater; 300°F (149°C) for 3 hours; 200 psig air
√ *No. of tests per series:* four tests performed simultaneously

At the conclusion of the test, the stressed fuel from each bomb is filtered through a 1-micron Gelman glass filter. The filters are analyzed for surface carbon using a LECO RC-412 Carbon Determinator.

Five Fuel Reactors were fabricated. The fuel reactors were basically 9-inch X $1^1/_4$ inch O.D. stainless steel bombs. A two-way valve is used to introduce the desired atmosphere and pressure. Swage-type fittings allow disassembly for cleaning the reactor and loading the test fuel. A 75-milliliter (mL) Pyrex glass test tube is used to prevent contact of the fuel and minimize contact of its vapor with the metal reactor walls. Four reactors can be thermally stressed simultaneously using a four-port Corrosion Oxidation Stability (COS) aluminum-block heater. Optimum test times, temperatures and pressures were determined.

The Fuel Reactor test provides a number of advantages over that of the MTP test. These include smaller sample size, post test filtering of the entire aliquot thermally stressed, less labor intensive and performance of up to four tests simultaneously. Preliminary testing showed that the Fuel Reactor test ranked fuels of varying propensity for thermal precipitation in the same order as the MTP test. Repeatability and discrimination between fuels was as good or better than the MTP test. Appendix C presents a ranking of additives based on the Fuel Reactor test as well as a master list of all replicate runs performed.

• *Hot Liquid Process Simulator Test*

The Hot Liquid Process Simulator (HLPS) was selected as the primary tool for screening additives. A detailed description of the technique and how it was applied in screening candidate thermal stability improving additives is described in "Task III - Screening and Evaluation of Candidate Additives." Further, Task III presents a comprehensive ranking of all reference fuels, additives, and experimental blends based on HLPS test results.

• *Isothermal Corrosion Oxidation Test*

The Isothermal Corrosion Oxidation Test (ICOT) was developed by WL for use in screening additives. Because of its ease of setup and quickly established database at WL, it was implemented at P&W as a tool for monitoring bulk fuel insolubles produced during thermal stressing of fuel/additive formulations. A detailed description of the technique and how it was applied in screening candidate thermal stability improving additives is described in "Task III - Screening and Evaluation of Candidate Additives." Further, Task III presents a comprehensive ranking of all reference fuels, additives, and experimental blends.

• *Quartz Crystal Microbalance*

A Quartz Crystal Microbalance (QCM) developed by Sandia National Laboratories (SNL) demonstrated the ability to monitor deposition rate in real time in a static reactor vessel. As a result of technical discussions at WL and SNL, a QCM was evaluated at P&W and University of Dayton Research Institute (UDRI) for use in screening additives. P&W teamed with SNL and UDRI in test method development for static applications.

Preliminary testing showed the technique to be very promising. The test appears to lend itself to routine analysis. An investigation was conducted directed at evaluating the affect of time, temperature, and atmosphere on test repeatability and differentiation between fuel types and additives. The test has been implemented for use in evaluating additives.

Task II - Procurement and Blending of Fuel/Additive Formulations

One hundred fifty two additives were received from 19 additive manufacturers and distributors for screening. A current inventory showing additive category, manufacturer, blending concentration and chemical description is included in Appendix A at the end of this report.

Task III - Screening and Evaluation of Candidate Additives

• *Hot Liquid Process Simulator Test*

All additives in inventory were screened using the HLPS. A comprehensive HLPS ranking of the reference fuels and additives evaluated is shown in Table 2-1. Figure 2-1 is a graphical representation of the HLPS ranking for the 50 best performing reference fuels and additives. Ranking of the reference fuels and candidate additives is based on surface carbon produced during a 5-hour HLPS test performed at 635°F (335°C) using a 316 series stainless steel JFTOT tube. Where multiple tests were performed, the value shown is an average of the replicate runs. Appendices A through C present master lists of all replicate HLPS, ICOT, MTP, and Fuel Reactor tests performed.

An "Index of Merit" was applied to the additives evaluated in the HLPS test. The formula was used to identify the most promising additives. These additives will be considered for advancement to a second level of screening. Secondary screening will subject the additives to screening in several fuels, package reformulation and concentration optimization, then onward to larger scale flowing tests such as the Phoenix Rig, Augmentor Rig, and the Extended Duration Test. The Index of Merit considers the baseline fuel in which the additive was evaluated and performance in relation to the JP-TS target. Considered for secondary screening are those additives which show a carbon reduction ≥ DuPont JFA-5. JFA-5 is the only thermal stability improving additive approved by military specification. Currently, it is considered state of the art.

- *Isothermal Corrosion Oxidation Test*

In the Isothermal Corrosion Oxi-dation Test (ICOT), performance of the reference fuels and candidate additives is based on carbon produced during a 5-hour test performed at 356°F (180°C). A 70-mL aliquot of fuel is stressed in a 38-millimeter (mm) OD X 300-mm glass COS tube using a multiport aluminum block heater. A 0.25-inch O.D. X 30-inch glass blower tube bubbles air into the fuel at a rate of 1L/hour. Condenser temperature is 68°F (20°C). At the conclusion of the test, the entire aliquot of fuel is filtered through a 1-micron Gelman glass filter. The blower tube and the filter are rinsed with hexane. The filter is dried in an oven prior to carbon burnoff. A LECO RC-412 Carbon Determinator is used to measure surface carbon formed on the glass blower tube and bulk fuel insolubles collected on the Gelman glass filter.

ICOT were performed on 21 additives. Each additive was tested in duplicate. Priority was placed on testing those additives shown to be most promising in HLPS tests.

Reference and target fuels, along with additives screened to date, are ranked in Table 2-2. These are shown in order of increasing bulk fuel insolubles. Blower tube surface carbon is also shown. The value shown is an average of two to four runs. Appendix A presents a master list of all replicate ICOT tests. Standard deviation and coefficient of variation is included for some tests to give insight into the repeatability exhibited by the ICOT. Statistical analysis shows that the ICOT should be considered as a "ball park" screening test.

TABLE 2-1
HLPS RANKING OF FUELS, ADDITIVES, AND EXPERIMENTAL BLENDS

Product Name	*Carbon ($\mu g/cm^2$)*	*Delta P/Time (mm Hg/min.)*	*Product Name*	*Carbon ($\mu g/cm^2$)*	*Delta P/Time (mm Hg/min.)*
Exxon JP-TS	3		POSF 2942	41	300/240
JP-TS Non-Add. Sp. Blend	5	4/300	POSF 2786, 11 mg/L	44	0/300
AF JP-TS	6	1/300	POSF 2786 + 2856	44	
Super K-1	7	0/300	POSF 2901	44	300/300
POSF 2881 + 2786	9	300/25	POSF 2773	45	4/300
POSF 2843 + 2894	12	5/300	POSF 2742	46	300/90
POSF 2908	13	300/5	POSF 2769	46	300/45
POSF 2881 + 2913	13	255/165	POSF 2941	46	5/300
POSF 2913	15	300/180	POSF 2851	47	300/180
POSF 2881	16	300/6	POSF 2879	47	300/54
POSF 2786 + 25 mg/L 2843	16	19/300	POSF 2924	47	300/90
POSF 2843 +2730	16	5/300	POSF 2910	47	300/40
POSF 2894	16	0/300	POSF 2730, 300 mg/L	48	4/300
Super K-1 + POSF 2904	17		POSF 2786, 50 mg/L	48	
POSF 2904 + 25 mg/L 2843	18	300/30	POSF 2880	48	300/120
POSF 2895	20	2/300	POSF 2741	48	22/300
POSF 2843 + 2904 + 2913	21	8/300	POSF 2884	49	300/94
POSF 2786 + 12 mg/L 2843	22	5/300	POSF 2912	50	176/300
POSF 2843 + 2914	22	300/240	POSF 2996	50	300/23
POSF 2904 + 2851 + 2786	23		POSF 2943	50	0/300
POSF 2843	24	300/20	POSF 2737	51	23/300
POSF 2843 + 2913	24	9/300	POSF 2902	51	300/150
POSF 2926 Shell Oil Jet A	24	5/300	POSF 2946	51	0/300
POSF 2789	24	300/60	POSF 2903	52	300/300
POSF N1	25	300/90	POSF 2730, 5 mg/L	52	1/300
POSF 2904	25	300/40	POSF 2772	53	300/210
POSF 2777	25	300/12	POSF 2733, 5 mg/L	54	0/300
POSF2944	25	300/210	POSF 2763	54	300/210
Jet A-1 Ref. +POSF 2904	26		POSF 2881 + 2914	54	300/33
POSF 2905	26	300/4	POSF 2914	55	4/300
POSF 2780	27	300/30	POSF 2947	55	1/300
POSF 2842	27		POSF 2898	56	300/180
POSF 2739	28	300/150	POSF 2788	56	300/300
POSF 2743	29	7/300	POSF 2938	57	300/145
POSF 2778	32	300/56	POSF 2768	58	300/73
POSF 2786, 100 mg/L	32		POSF 2734	61	120/300
POSF 2949	32	4/300	POSF 2767	63	
POSF 2899	33	300/240	POSF 2841	64	300/45
POSF 2907	33	300/10	POSF 2839	65	
POSF 2854	34		POSF 2868	65	300/60
POSF 2921	34	300/120	POSF 2894 + 2727	65	300/180
POSF 2948	34	300/150	POSF N4	66	238/300
POSF 2911	35	300/39	POSF 2770	66	
POSF 2787	36	300/90	POSF 2945	68	0/300
Exxon Jet A w/ 15% HC Stock	37	256/300	POSF 2760	69	
POSF 2906	37	10/300	POSF 2732	69	7/300
POSF 2733, 300mg/L	37	5/300	POSF 2835	70	300/10
POSF 2950	38	5/300	POSF 2790	71	300/17
POSF 2909	38	300/30	POSF 2870	72	
POSF 2940	38	1/300	POSF 2849	72	4/300
POSF 2856, 25 mg/L	40	300/113	POSF 2845	73	5/300
POSF 2927	40	300/60	POSF 2877	74	300/36
POSF 2939	41	300/153	POSF 2846	75	

Note: The average value is shown for replicate runs
See Appendix A for concentrations

Table continued next page

TABLE 2-1 Continued
HLPS RANKING OF FUELS, ADDITIVES, AND EXPERIMENTAL BLENDS EVALUATED TO DATE

Product Name	*Carbon ($\mu g/cm^2$)*	*Delta P/Time (mm Hg/min.)*	*Product Name*	*Carbon ($\mu g/cm^2$)*	*Delta P/Time (mm Hg/min.)*
POSF 2833	78		POSF 2873	106	
POSF 2856, 100 mg/L	79		POSF 2782	106	
POSF 2756	80		POSF 2735	106	300/60
POSF 2731	82	1/300	POSF 2853	107	
POSF 2785	85	300/70	POSF 2864	107	
POSF 2867	86	300/90	POSF 2952	108	300/150
POSF 2771	86		POSF 2757	108	
POSF 2867	86	300/90	POSF 2775	109	
POSF 2771	86		POSF 2784	112	
POSF 2728	88	8/300	POSF 2783	112	
POSF 2766	88		POSF 2752	113	
POSF 2766	88		POSF 2862	114	
POSF 2838	89	300/30	POSF 2872	117	300/5
POSF 2847	90	5/300	POSF 2844	122	
POSF 2858	90		POSF 2859	123	
POSF 2745	90	0/300	POSF 2758	133	300/20
POSF 2897	91		POSF 2761	136	
POSF 2837	91		POSF 2785	141	
POSF 2764	91		POSF 2726	142	
POSF 2737	93	4/300	POSF 2776	144	
POSF 2736	93	300/120	Jet A-1 Ref. Fuel	152	300/60
POSF 2860	93		POSF 2874	154	300/51
POSF 2754	95		POSF 2951	160	1/300
POSF 2781	96		POSF 2861	163	
POSF 2832	97		POSF 2738	218	300/182
POSF 2836	98	300/60	POSF 2850	227	
POSF 2900	98		POSF 2774	262	
POSF 2751	98		POSF 2848	272	5/300
POSF 2840	98		POSF 2744	288	
POSF 2762	99		POSF 2727	342	300/270
POSF 2878	100	300/36	POSF 2729	386	6/300
POSF 2865	100		POSF 2759	1404	18/300
POSF 2765	101		POSF 2881 + 2759	1504	11/300
POSF 2748	102		POSF 2834	Insoluble	
POSF 2753	104		POSF 2871	Insoluble	
POSF 2869	104		POSF 2866	Insoluble	
POSF 2863	104		POSF 2876	**	300/20
POSF 2883	105		POSF 2855	**	
POSF 2735	106	300/60	POSF 2866	Insoluble	
POSF 2755	106		POSF 2876	**	300/20
POSF 2852	106		POSF 2855	**	

Note: The average value is shown for replicate runs
See Appendix A for concentrations

** plugged fuel line

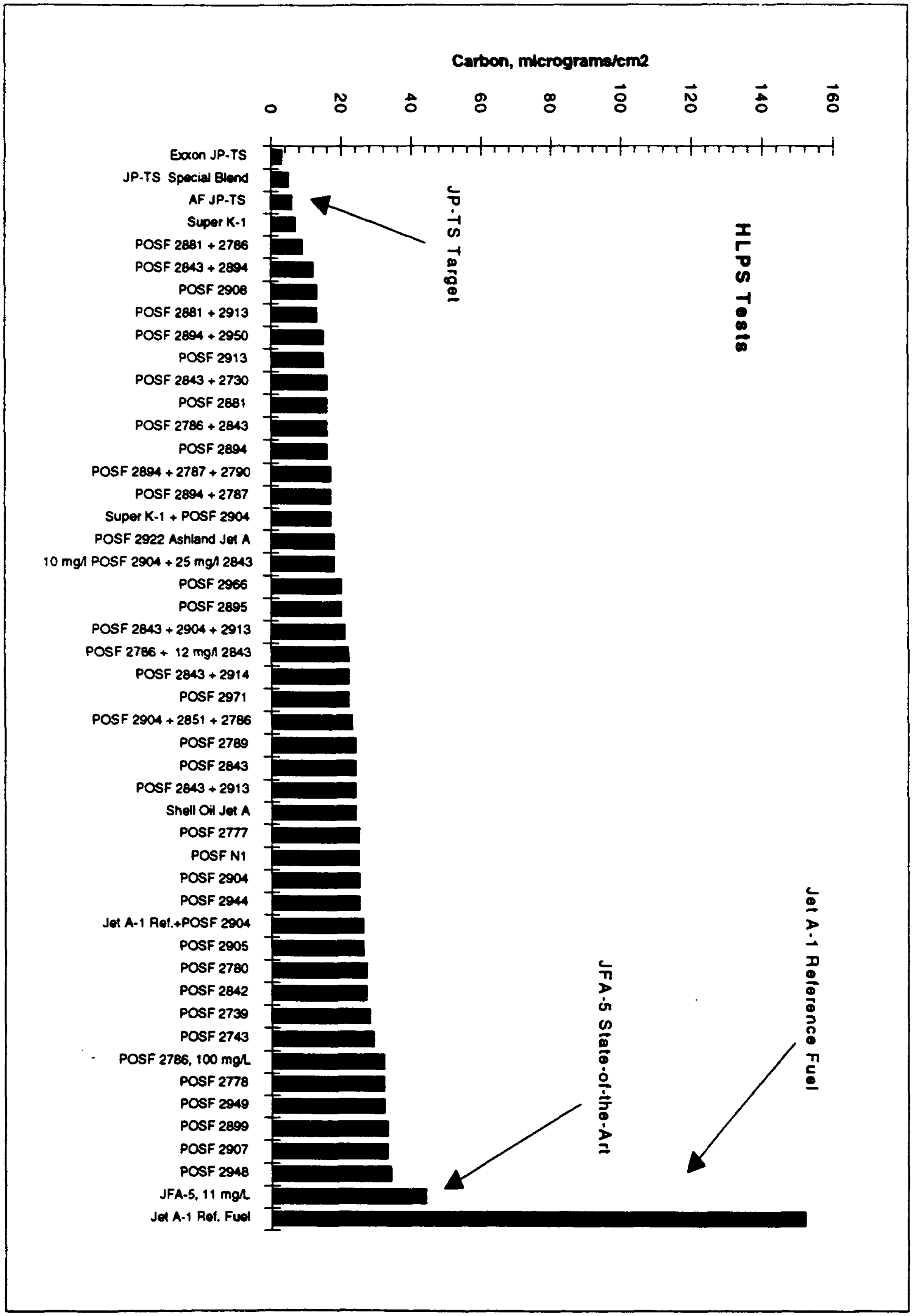

Figure 2-1. HLPS Ranking of the Top 50 Reference Fuels and Additive Blends

TABLE 2-2
ICOT RANKING OF FUELS, ADDITIVES, AND EXPERIMENTAL BLENDS

Sample Name	*Filtered Carbon Avg, μg*	*Blower Tube Carbon Avg, μg*	*Sample Name*	*Filtered Carbon Avg, μg*	*Blower Tube Carbon Avg, μg*
POSF 2894	397	590	POSF 2842	1148	567
POSF 2894+ 2727	468	68	POSF 2843	1166	553
POSF 2950	491	99	POSF 2789	1202	721
POSF 2909	494	324	POSF 2777	1204	662
POSF 2739	494	340	POSF 2913	1232	759
POSF 2884	528	564	POSF 2832	1272	[illegible]
POSF 2769	529	726	POSF 2951	1288	[illegible]
JP-TS	*584*	*74*	POSF 2949	1320	[illegible]
POSF N1	598	377	POSF 2741	1388	750
POSF 2880	604	424	POSF 2908	1391	569
POSF 2910	610	567	POSF 2927	1456	351
POSF 2944	650	393	POSF 2849	1457	225
POSF 2733	654	951	POSF 2786	1486	438
POSF 2773	666	721	POSF 2848	1672	468
POSF 2778	747	594	POSF 2901	1675	902
POSF 2787	785	100	POSF 2879	1710	541
POSF 2856, 25 mg/L	836	527	POSF 2847	1768	547
POSF 2907	862	309	Shell Jet A-1	1879	2417
POSF 2780	874	519	POSF 2845	1925	516
POSF 2939	874	505	POSF 2854	2016	562
POSF 2899	877	611	POSF 2895	2055	671
POSF 2856, 100 mg/L	883	707	POSF 2846	2104	605
POSF 2904	891	434	POSF 2952	2221	702
POSF 2786	*900*	*497*	POSF 2742	2365	1105
POSF 2948	908	169	POSF 2851	2574	1727
Super K-1	947	97	POSF 2727	2944	113
POSF 2844	1009	2542	*Jet A Ref.*	*2971*	*3196*
POSF 2905	1045	321	POSF 2743	3655	642
POSF 2921	1046	414	POSF 2730	3938	398

Note: See Appendix A for repeatability

4.0 CONCLUSIONS

Based on HLPS tests, the most promising additives were those that significantly reduced both surface carbon and differential pressure. As shown in Table 2-1, three out of the top four performers were experimental blends that included POSF 2843 antioxidant. The fourth was a detergent/dispersant identified as POSF 2895. Based on ICOT tests, the most promising additives were those that significantly reduced both filtered carbon and blower tube carbon. One experimental blend, POSF 2894 + POSF 2727, and one single additive, POSF 2950, yielded lower filtered carbon than did JP-TS. POSF 2894 + POSF 2727 yielded both lower filtered carbon and blower tube carbon than the JP-TS target.

In addition to the above additives, a number of other candidates have been identified that in combination are expected to further the goal of meeting or exceeding the thermal stability properties of JP-TS. Considerable more work remains in the area of additive screening, experimental blends, test development and interpretation, second-level screening, larger-scale dynamic flowing tests, material compatibility, physical and chemical characterization, and com-ponent and engine tests.

The data generated and "lessons learned" during the course of this program have been transitioned to a follow-on Air Force funded effort entitled "An Integrated Approach to Improved Fuel System Design and Fuel Thermal Stability." The aforementioned program will continue the pursuit of the goals and objectives formulated for development and implementation of JP8+100.

5.0 APPENDICES

The following section includes Appendices A through C. Appendix A presents all HLPS and ICOT results; Appendix B all MTP results; and Appendix C all Fuel Reactor test results. Appendix A has been updated to include results compiled subsequent to the end of this technical effort.

APPENDIX A: APPA_FIN.XLS

HLPS AND ICOT TEST RESULTS

Revised 12/02/93

POSF Number	Conc. mg/L	HLPS Carbon ug/cm2	HLPS ΔP mm Hg / Min.	HLPS Burn Off Date	ICOT Blower Tube Carbon, ug	ICOT Filter Carbon ug	ICOT Burn Off Date	Description / Supplier Recommended Dosage, mg/L
91-POSF-2855	25	Plugged	2 hrs into run	12/6/91				AO (N type). Mixed polycycloaliphatic amines / 75 mg/L.
	100	66	238 in 300	3/11/92				AO (O type). Benzyl alcohol
91-POSF-2856	100	79		9/24/91	780	923	1/11/93	AO (O type). tert-Butylhydroquinone (TBHQ)
					634	842		
					707	883	Avg.	
Retest at:	25	20	300 in 60	3/27/92	462	805	1/11/93	
		57	300 in 60	4/3/92	591	866		
		44	300 in 220	4/24/92	527	836	Avg.	
		Avg: 40						
92-POSF-2899	25	33	300 in 240	3/3/92	603	867	12/10/92	AO (O type). 1-butanone oxime
					618	886		
					611	877	Avg.	
92-POSF-2897	25	91		10/10/91				AO (O type - vapor phase). 2-butene-1,4-diol
92-POSF-2900	25	98		8/14/91				AO (O type - vapor phase). Cyclohexanone oxime
92-POSF-2898	25	56	300 in 180	3/3/92	404	597	2/22/93	AO (O type - vapor phase). 2-cyclohexen-1-one
					341	413		
					373	505	Avg.	
90-POSF-2751	125	115		7/15/91				Stabilizer/Dispersant. Aliphatic sulfonate subsituted aromatic,
		82		8/14/91				MDA + color stabilizer. 100-125 mg/L.
92-POSF-2895	100	20	2 in 300	8/25/92	569	2180	10/19/92	Detergent/Dispersant. Petromeen AF-114, Proprietary
					888	2476		
					647	1691		
					581	1871		
					671	2055	Avg	
92-POSF-2924	10	47	300 in 90	4/24/92	412	690	1/13/93	
					373	609		
					393	650	Avg.	
92-POSF-2901	100	44	300 in 300	8/3/92	879	1780	1/11/93	Proprietary stabilizer
					924	1570		
					902	1675	Avg.	

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HLPS AND ICOT TEST RESULTS

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POSF Number	Conc. mg/L	HLPS Carbon ug/cm2	HLPS ΔP mm Hg / Min.	HLPS Burn Off Date	ICOT Blower Tube Carbon, ug	ICOT Filter Carbon ug	ICOT Burn Off Date	Description / Supplier Recommended Dosage, mg/L
92-POSF-2902	10	51	300 in 150	4/10/92	796	1408	2/22/93	Proprietary MDA
					948	1430		
					872	1419	Avg.	
90-POSF-2790	100	71	300 in 17*	10/5/92	541	1656	5/24/93	Proprietary stabilizer (*Line plugged at 150 minutes)
					580	1607		
					561	1632	Avg.	
92-POSF-2903	100	52	300 in 30	8/3/92	442	1019	2/22/93	Proprietary stabilizer
					435	1038		
					439	1029	Avg.	
90-POSF-2787	10	36	300 in 90	4/10/92	101	784	1/11/93	SPEC-AID 8Q400, Proprietary MDA. / 6 ppm
					98	785		
					100	785	Avg.	
92-POSF-2894	100	19	0 in 300	8/25/92	474	406	10/6/92	Detergent/Dispersant. (Thermoflo 7R19)
Repeat	100	13	5 in 300	11/4/92	603	413		
					542	373		
	50				741	397		
					590	397	Avg.	
Repeat ICOT					1536	2057	2/22/93	
					972	1914		
					1254	1986	Avg.	
	100				1660	1320	5/25/93	
Repeat ICOT using mass flow controller					2110	942		
					1885	1131	Avg.	
POSF N3	100							Detergent / Dispersant (Thermoflo 7R30)
91-POSF-2858	25	90		12/16/91				AO (O type). 2,2-Bis(4-hydroxyphenyl)butane
91-POSF-2859	25	123		12/16/91				AO (O type). 4-tert-butylcatechol
91-POSF-2860	25	93		11/25/91				AO (O type). 2,5-di-t-butylhydroquinone

HLPS AND ICOT TEST RESULTS

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		HLPS			ICOT			
POSF Number	Conc. mg/L	Carbon ug/cm2	ΔP mm Hg / Min.	Burn Off Date	Blower Tube Carbon, ug	Filter Carbon ug	Burn Off Date	Description / Supplier Recommended Dosage, mg/L
91-POSF-2861	25	163		11/25/91				AO (O type). Hydroquinone monobenzylether
91-POSF-2862	25	114		11/25/91				AO (O type). Hydroquinone monomethylether
91-POSF-2863	25	104		12/16/91				AO (O type). 2,2'-methylene bis(6-t-butyl-4-methylphenol)
91-POSF-2864	25	107		12/16/91				AO (O type). 4,4'-methylene bis(2,6-di-t-butylphenol)
91-POSF-2865	25	100		11/8/91				AO (O type). Pentaerythrityl tetra bis(3,5-di-t-butyl-4-
								hydroxycinnamate).
91-POSF-2866	25	Insoluble						AO (O type). Propyl gallate
91-POSF-2867	25	86	300 in 90	1/17/92				AO (O type). 2,4,6-tris(3,5-di-t-butyl-4-hydroxyphenyl)-
								mesitylene.
91-POSF-2868	25	65	300 in 60	1/17/92				AO (O type). Tris(2-methyl-4-hydroxy-5-t-butylphenyl)butane
91-POSF-2869	25	104		10/10/91				AO (O/S type). 4,4'-Thiobis(2,6-di-t-butylphenol)
91-POSF-2870	25	72		12/16/91				AO (O/N type). 2,6-di-t-butyl-o-dimethylamino-p-cresol
91-POSF-2871	25	Insoluble						AO (O/N type). N-lauroyl-p-aminophenol
91-POSF-2872	25	117	300 in 5	3/3/92				AO (O/N type). 2,4,6-tris(dimethylaminomethyl)phenol
91-POSF-2873	25	106		12/16/91				AO (N type). N,N'-bis(1,4-dimethylpentyl)-p-phenylenediamine
91-POSF-2874	25	154		1/17/92				AO (N type). N,N'bis(1-ethyl-3-methyl-pentyl)-p-phenylene-
92-POSF-2896	25	50	300 in 23	3/3/92	743	906	2/22/93	AO (O/N type). Di-p-methoxydiphenylamine
					941	1372		
					842	1139	Avg.	
91-POSF-2875	25	85	300 in 70	1/17/92				AO (N type). Dioctyldiphenylamine ("DODPA")
91-POSF-2876	25	Plugged	300 in 20	1/17/92				AO (N type). N,N'-diphenyl-p-phenylenediamine ("DPPD")
91-POSF-2877	25	74	300 in 36	2/5/92				AO (N type). N,N-di-2-naphthyl-p-phenylenediamine
91-POSF-2878	25	100	300 in 36	2/5/92				AO (N type). N-phenyl-N'-cyclohexyl-p-phenylenediamine
91-POSF-2879	25	47	300 in 54	1/17/92	618	2300	1/14/93	AO (N type). N-phenyl-1-naphthylamine ("PANA")
					463	1120		
					541	1710	Avg.	
91-POSF-2880	25	48	300 in 120	3/3/92	425	571	1/14/93	AO (N/S type). p-(p-toluenesulfonamide)diphenylamine
					423	637		
					424	604	Avg.	
91-POSF-2881	25	16	300 in 2	2/5/92				AO (N type). m-toluylenediamine (toluene-2,4-diamine)
Repeat	25	16	300 in 10	2/21/92				
91-POSF-2883	25	105		10/30/91				AO (O/S type). Dilaurylthiodipropionate
91-POSF-2884	25	49	300 in 94	1/17/92	608	575	1/14/93	AO (O type). Methylhydroquinone
					519	481		
					564	528	Avg.	

HLPS AND ICOT TEST RESULTS

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		HLPS			ICOT			
POSF Number	Conc. mg/L	Carbon ug/cm2	ΔP mm Hg / Min.	Burn Off Date	Blower Tube Carbon, ug	Filter Carbon ug	Burn Off Date	Description / Supplier Recommended Dosage, mg/L
90-POSF-2741	300	48	22 in 300	8/25/92	702	1312	1/13/93	Detergent / Dispersant for diesel fuel. 1500 mg/L.
					797	1463		
					750	1388	Avg.	
90-POSF-2742	25	46	300 in 90	10/5/92	1261	2542	1/11/93	Antioxidant Package for diesel fuel. 50 mg/L.
					948	2188		
					1105	2365	Avg.	
90-POSF-2743	300	29	7 in 300	10/5/92	635	3548	12/9/92	Detergent / Dispersant for diesel fuel. 1500 mg/L.
					649	3761		
					642	3655	Avg.	
90-POSF-2744	1000	288		6/18/91				Detergent/Dispersant for gasolines. 1500 mg/L.
Drum #2	300	68	6 in 300	10/15/92				
90-POSF-2745	300	90	0 in 300	10/5/92				Detergent/Dispersant for gasolines. 1500 mg/L.
92-POSF-2927	25	43	300 in 94	6/11/92	370	1433	1/11/93	AO (N type). N,N'-di-isopropyl-p-phenylene diamine
Repeat		36	300 in 25	6/26/92	331	1478		
		Avg: 40			351	1456	Avg.	
91-POSF-2851	25	120		10/18/91	1647	2585	1/11/93	AO (O type). 2,6-di-t-butyl-4-methylphenol (BHT,
Repeat		47	300 in 180	6/11/92	1807	2562		IONOL) / 16 - 32 mg/L.
					1727	2574	Avg.	
92-POSF-2912	5	50	176 in 300	6/3/92	281	902	2/22/93	Proprietary Dispersant (Methacrylate type) / 5 mg/L
					383	967		
					332	935	Avg.	
92-POSF-2913	5	15	300 in 180	3/27/92	697	1603	12/9/92	Proprietary Dispersant (Styrene monomer) / 5 mg/L
					821	861		
					759	1232	Avg.	
Repeat	5				384	1141	2/24/93	
					414	1084		
					399	1113	Avg.	

HLPS AND ICOT TEST RESULTS

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		HLPS			ICOT			
POSF Number	Conc. mg/L	Carbon ug/cm2	ΔP mm Hg / Min.	Burn Off Date	Blower Tube Carbon, ug	Filter Carbon ug	Burn Off Date	Description / Supplier Recommended Dosage, mg/L
92-POSF-2914	5	55	4 in 300	5/29/92	462	892	2/24/93	Proprietary Dispersant / 5 mg/L
					515	819		
					489	856	Avg.	
90-POSF-2786	11	49	0 in 300	6/15/91	288	867	10/5/92	AO/Disp./MDA. Prop. comp. / methacrylate polymer
		47		6/17/91	511	925		+ MDA. / 12 mg/L.
		49		6/20/91	576	927		
		40		7/15/91	613	882		
		33		7/15/91	497	900	Avg.	
		37		7/15/91	146	30	S.D.	
	11	29	0 in 300	6/26/92	929	1182	5/20/93	Duplicate HLPS tests performed by two different operators on
	11	30	0 in 300	6/26/92	795	1070		the same day.
					862	1126	Avg.	
	50	40		9/11/91	546	1297	1/13/93	
		57		9/11/91	330	1674		
		Avg: 49			438	1486	Avg.	
	100	36		9/11/91				
		29		9/11/91				
POSF N1	10	25	300 in 90	3/27/92	355	596	12/8/92	Same as MDA / 5.8 ppm Max.
					398	599		
					377	598	Avg.	
92-POSF-2904	10	26		11/8/91				
92-POSF-2905	10	24	300 in 4	4/15/92	306	1084	12/8/92	MDA. N,N'-disalicylidene-1,2-diaminocyclohexane &
					335	1006		solvent. 5.8 mg/L.
					321	1045	Avg.	
	10	28	300 in 5	4/24/92				
92-POSF-2904	10	25	300 in 40	4/3/92	409	899	12/8/92	MDA. N,N'-disalicylidene-1,2-propanediamine &
					459	883		solvent. / 5.8 mg/L.
					434	891	Avg.	
91-POSF-2852	25	106		10/18/91				AO (N type). Organic Amines / 60 mg/L.

HLPS AND ICOT TEST RESULTS

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		HLPS			ICOT			
POSF Number	Conc. mg/L	Carbon ug/cm2	ΔP mm Hg / Min.	Burn Off Date	Blower Tube Carbon, ug	Filter Carbon ug	Burn Off Date	Description / Supplier Recommended Dosage, mg/L
91-POSF-2853	25	107		10/18/91				AO (N type). Amino Amide / 100 mg/L.
91-POSF-2854	25	34		10/18/91	601	2081	12/11/92	AO/MDA. Organic Amines + Metal deactivator. 64 mg/L.
Repeat	50	45	300 in 210	10/5/92	522	1951		Repeat test to evaluate at supplier recommended dosage.
					562	2016	Avg.	
92-POSF-2906	25	33	1 in 300	5/1/92	607	794	12/16/92	Same as JFA-5, except different dispersant
Repeat	25	41	18 in 300	6/26/92	483	889		
					545	842	Avg.	
92-POSF-2907	25	33	300 in 10	5/1/92	290	881	12/11/92	Similar to JFA-5, except different AO and dispersant
					328	843		
					309	862	Avg.	
92-POSF-2908	25	13	300 in 5	5/1/92	575	1238		Same as JFA-5, except different dispersant
					439	1181		
					666	1569		
					596	1576		
					569	1391	Avg	
92-POSF-2909	25	38	300 in 30	5/1/92	315	473	1/11/93	Similar to JFA-5, except different AO and Dispersant
					333	514		
					324	494	Avg.	
92-POSF-2910	25	47	300 in 40	5/1/92	434	621	1/13/93	Two different AO types + DMD @ 40% found in JFA-5
					700	599		
					567	610	Avg.	
92-POSF-2911	25	35	300 in 39	5/1/92	616	877	12/16/92	Three different AOs + DMD @ 60% found in JFA-5
					535	923		
					576	900	Avg.	
92-POSF-2921	25	35	300 in 120	5/1/92	448	936	12/11/92	Different from JFA-5: Proprietary
					380	1156		
					414	1046	Avg.	

APPENDIX A: APPA_FIN.XLS

HLPS AND ICOT TEST RESULTS

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POSF Number	Conc. mg/L	HLPS Carbon ug/cm2	HLPS ΔP mm Hg / Min.	HLPS Burn Off Date	ICOT Blower Tube Carbon, ug	ICOT Filter Carbon ug	ICOT Burn Off Date	Description / Supplier Recommended Dosage, mg/L
POSF N5	25							AO in JFA-5 (Amino Amide)
93-POSF-2988	15							New' JFA-5
90-POSF-2748	200	102		6/20/91				Stablizer / extender. "Animal and vegetable fats"...?!
90-POSF-2758	100	133	300 in 20	8/25/92				Detergent / Dispersant. Imidazoline, substituted fatty
90-POSF-2752	25	113		10/30/91				AO (O type). 98% 2,6-di-t-butylphenol + others. 24 mg/L.
90-POSF-2753	25	104		6/20/91				AO (O/N type). 98% min. 2,6-di-t-butyl-.alpha.-dimethylamino-
90-POSF-2754	25	95		10/10/91				AO (O type). 97.5% 4,4'-methylene-bis(2,6-di-t-butyl-
90-POSF-2757	25	108		11/25/91				AO (O type). Mixture of t-butylphenols. / 24 mg/L.
90-POSF-2755	25	106		12/16/91				AO (O type). Mixture of t-butylphenols. 24 mg/L.
90-POSF-2756	25	80		11/15/91				AO (O type). 2,6-di-t-butylphenol + solvent. 24 mg/L.
91-POSF-2832	25	97		11/25/91	1134	1378	12/7/92	AO (N type). Aromatic amine
					1349	1165		
					1242	1272	Avg.	
91-POSF-2833	25	78		10/10/91				AO (O/S type). Thioamine
91-POSF 2834	25	Insoluble						AO (N type). Aromatic amine
91-POSF-2835	25	70	300 in 10	2/5/92				AO (N type). Aromatic amine
91-POSF-2836	25	98	300 in 60	2/5/92				AO (N type). Aromatic amine
91-POSF-2837	25	91		12/16/91				AO (N type). Aromatic amine
91-POSF-2838	25	93	300 in 30	2/5/92				AO (N type). Aromatic amine
Repeat		85	300 in 75	2/5/92				
91-POSF-2839	25	65		11/8/91				AO (N type). Aliphatic amine
91-POSF-2840	25	98		10/30/91				AO (N type). Aromatic amine
91-POSF-2841	25	173		10/18/91				AO (N/O type). Amino ether
Repeat		64	300 in 60	2/21/92				
Repeat		64	300 in 60	3/3/92				
91-POSF-2842	25	27		10/18/91	347	1162	12/7/92	AO (O type). Phenol
		50	3 in 300	3/27/92	787	1134		
		25	300 in 14	4/3/92	567	1148	Avg.	
		Avg: 34						
91-POSF-2843	25	24	300 in 20	11/15/91	567	1082	11/4/92	AO (O type). Phenol

APPENDIX A: APPA_FIN.XLS

HLPS AND ICOT TEST RESULTS

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		HLPS			ICOT			
POSF Number	Conc. mg/L	Carbon ug/cm2	ΔP mm Hg / Min.	Burn Off Date	Blower Tube Carbon, ug	Filter Carbon ug	Burn Off Date	Description / Supplier Recommended Dosage, mg/L
					482	1256		
					611	1126		
					550	1198		
					553	1166	Avg	
91-POSF-2844	25	122		11/25/91	2470	932	11/4/92	AO (O type). Phenol
					2476	1230		
					2549	960		
					2673	914		
					2542	1009	Avg	
91-POSF-2845	100	73	1 in 300	8/3/92	531	1999	10/19/92	Low MW detergent + high MW N2 dispersant + AO & sol.
					582	2087		
					464	1868		
					486	1748		
					516	1925	Avg	
91-POSF-2846	100	75		10/10/91	468	2105	10/20/92	Low MW detergent + high MW N2 dispersant + AO & sol.
					652	2073		
					693	2140		
					605	2097		
					605	2104	Avg	
91-POSF-2847	100	.90	0 in 300	8/3/92	552	2225	10/20/92	Low MW deterg. + high MW N2 disp. + AO & sol. oil.
					326*	1393		
					750	1687		* Deposit "ring" came off blower tube and onto filter during
					559	1765		hexane rinse.
					547	1768	Avg	
91-POSF-2848	100	272	0 in 300	8/3/92	416	1590	12/7/92	Low MW deterg. + high MW N2 disp. + AO & solvent.
					519	1754		
					468	1672	Avg.	
91-POSF-2849	100	72	0 in 300	8/3/92	189	1071	12/7/92	Low MW deterg. + high MW N2 disp. + AO & solvent.
					260	1842		
					225	1457	Avg.	

APPENDIX A: APPA_FIN.XLS

HLPS AND ICOT TEST RESULTS

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		HLPS			ICOT			
POSF Number	Conc. mg/L	Carbon ug/cm2	ΔP mm Hg / Min.	Burn Off Date	Blower Tube Carbon, ug	Filter Carbon ug	Burn Off Date	Description / Supplier Recommended Dosage, mg/L
POSF N2	100	69	300 in 100	6/2/93				30% 2, 2'-Bypridyl, 60% 1-Methyl-2 Pyrrolidinone &
								10% Dipropylene Glycol
90-POSF-2759	1000	1404	18 in 300	5/29/92				Disp. 1-Hydroxyethyl-2-heptadecenyl imidazoline. 1000 mg/L.
90-POSF-2785	25	141		7/15/91				Deterg. / Disp. Alkylphenol/formaldehyde resin/ aromatic
91-POSF-2850	50	227		10/10/91				naphtha and large chain alkylphenol/naphthalene/trimethyl-
	80	53		7/15/91				benzene. / 80 mg/L.
		130*	(Flow slowed	8/14/91				
		106*	- cause unk.)	8/14/91				
90-POSF-2766	25	88		12/16/91				AO (O type). MOBILAD C145, Alkyl phenol / 25 mg/L.
90-POSF-2767	25	63		10/18/91				AO (n type). MOBILAD C146, Aryl Amine. / 50 mg/L.
90-POSF-2726	1000	142		6/15/91				Detergent / Dispersant. Proprietary. 1500 mg/L.
90-POSF-2760	25	69		10/18/91				AO (O type). Alkyl phenol / 25 mg/L.
90-POSF-2727	300	342	300 in 270	7/10/92	IGNITED	2742		Detergent. Proprietary / 1500 mg/L.
					104	3010		
					130	3012		
					104	3011		
					113	2944	Avg	
90-POSF-2761	25	136		6/17/91				AO (N type). Aryl amine / 50 mg/L.
90-POSF-2762	25	99		11/8/91				AO (O type). Alkyl phenol / 25 mg/L.
92-POSF-2938	600	57	300 in 145	12/10/92				AO (O type). Alkyl Phenol / 570 to 856 mg/L
90-POSF-2733	300	37	5 in 300	7/10/92	641	644	1/11/93	Detergent, Proprietary / 1500 mg/L.
	5	54	0 in 300	8/14/92	1260	663		
					951	654	Avg.	
	300				213	347	2/22/93	Ref. Fuel Drum #3 fuel used.
					276	448		
					245	398	Avg.	
Repeat ICOT using mass flow controller								
	300				1220	467	5/25/93	
					1200	295		
					1210	381	Avg.	

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			HLPS AND ICOT TEST RESULTS					Revised 12/02/93
			HLPS			ICOT		
POSF Number	Conc. mg/L	Carbon ug/cm2	ΔP mm Hg / Min.	Burn Off Date	Blower Tube Carbon, ug	Filter Carbon ug	Burn Off Date	Description / Supplier Recommended Dosage, mg/L
92-POSF-2939	600	41	300 in 153	12/10/92	479	898	12/8/92	Experimental, Ether Ester / 570 to 856 mg/L (Clog Buster)
					531	850		
					505	874	Avg.	
90-POSF-2763	25	37		10/30/91	403	845	2/24/93	AO (O type). Aryl phenol / 25 mg/L.
Repeat	25	72	300 in 210	8/3/92	352	639		
					378	742	Avg.	
93-POSF-2970	25	50	300 in 120	3/12/93	1376	1235	5/24/93	Experimental alkylated phenol
					1606	966		
					1491	1101	Avg.	
93-POSF-2971	25	22	300 in 60	3/12/93	396	1777	5/24/93	Experimental alkylated phenol
					305	1710		
					351	1744	Avg.	
90-POSF-2734	300	61	120 in 300	7/10/92				Detergent, Proprietary / 1500 mg/L.
90-POSF-2764	25	91		12/16/91				AO (N type). Aryl amine / 50 mg/L.
90-POSF-2735	1000	106	300 in 60	5/29/92				Detergent, Proprietary / 1500 Mg/L.
90-POSF-2732	300	69	7 in 300	7/10/92				Detergent, Proprietary / 1500 mg/L.
90-POSF-2765	25	101		11/8/91				AO (N type). Aryl amine / 50 mg/L.
93-POSF-2972	25	55	300 in 150,	3/12/93	448	1153	5/24/93	Experimental alkylated triazole
					459	1280		
					454	1217	Avg.	
92-POSF-2948	600	34	300 in 150	11/4/92	177	877	12/11/92	AO (O type). Alkyl Phenol / 570 to 856 mg/L
					161	939		
					169	908	Avg.	
92-POSF-2940	600	38	1 in 300	12/10/92				AO (O type). Alkyl Phenol / 570 to 856 mg/L
92-POSF-2941	600	46	5 in 300	12/10/92				AO (O type). Alkyl Phenol / 570 to 856 mg/L
92-POSF-2942	600	41	300 in 240	12/10/92				Dispersant, Ether Succinimide / 570 to 856 mg/L
92-POSF-2943	600	50	0 in 300	12/10/92				Experimental, Ether Ester / 570 to 856 mg/L (Clog Buster)
92-POSF-2944	600	25	300 in 210	12/10/92				Arylamine Ester (AO & Detergent in one molecule)600 mg/L.
92-POSF-2950	600	38	5 in 300	11/4/92	84	418	1/11/93	Arylamine Ester (AO & Detergent in one molecule)600mg/L
					113	563		

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			HLPS AND ICOT TEST RESULTS					Revised 12/02/93
			HLPS			ICOT		
POSF Number	Conc. mg/L	Carbon ug/cm2	ΔP mm Hg / Min.	Burn Off Date	Blower Tube Carbon, ug	Filter Carbon ug	Burn Off Date	Description / Supplier Recommended Dosage, mg/L
					99	491	Avg.	
Repeat	600	39	0 in 300	3/12/93	360	1900	2/24/93	Ref. Fuel Drum #3 fuel used.
					621	3009		
					491	2455	Avg.	
Repeat ICOT using mass flow controller								
	600				232	671	5/25/93	
					234	612		
					233	642	Avg.	
92-POSF-2945	600	68	0 in 300	12/10/92				Dispersant, Ester / 570 to 856 mg/L
92-POSF-2949	600	32	4 in 300	11/4/92	112	1550	12/10/92	Ester (AO & Detergent in one molecule)600mg/L.
					106	1090		
					109	1320	Avg.	
92-POSF-2946	600	51	0 in 300	12/10/92				Dispersant, Ester / 570 to 856 mg/L
92-POSF-2947	600	55	1 in 300	12/10/92				Dispersant, Ester / 570 to 856 mg/L
93-POSF-2973	300	37	300 in 105	3/12/93	3598	1447	5/24/93	Alkylated Triazole
					2423	1465		
					3011	1456	Avg.	
93-POSF-2974	25	48	300 in 120	3/12/93	2896	1399	5/24/93	Alkylated Phenol
					2352	1374		
					2624	1387	Avg.	
93-POSF-2969	25	67	12 in 300	6/16/93	1010	1350	6/2/93	AO, N Type) Alkylated naphthylamine (NEW 4/93)
					*	1240		* Tube shattered when cut.
						1295	Avg.	
Repeat with new mass flow controller								
					1160	1290	6/16/93	
					1280	903		
					1220	1097	Avg.	
90-POSF-2730	300	48	4 in 300	7/10/92	405	4183	1/12/93	Detergents, Proprietary / 1500 mg/L.
	5	52	1 in 300	8/14/92	391	3692		
					398	3938	Avg.	

APPENDIX A: APPA_FIN.XLS

			HLPS AND ICOT TEST RESULTS					Revised 12/02/93
			HLPS			ICOT		
POSF Number	Conc. mg/L	Carbon ug/cm2	ΔP mm Hg / Min.	Burn Off Date	Blower Tube Carbon, ug	Filter Carbon ug	Burn Off Date	Description / Supplier Recommended Dosage, mg/L
Repeat					253	3270	2/22/93	
					324	3215		
					289	3243	Avg.	
90-POSF-2729	300	386	2 in 300	7/10/92				Detergents, Proprietary / 1500 mg/L.
Repeat	300	367	6 in 300	8/14/92				
90-POSF-2731	300	46	Line clogged	7/10/92				Detergents, Proprietary / 1500 mg/L.
Repeat	300	82	1 in 300	8/14/92				
90-POSF-2728	300	88	5 in 300	7/10/92				Detergents, Proprietary / 1500 mg/L.
90-POSF-2789	25	24	300 in 60	8/25/92	670	1242	12/10/92	AO/Disp./Stab. Amine substituted resin + aliphatic
					772	1161		amine. / 85 - 130 mg/L.
					721	1202	Avg.	
90-POSF-2768	100	58	300 in 73	10/5/92				Antifoulant. An alkyl aryl diamine. / 100 mg/L.
90-POSF-2769	100	46	300 in 45	10/5/92	873	559	1/11/93	Antifoul. An alkyl aryl diamine in heavy aro. naphtha. / 100
					579	498		
					726	529	Avg.	
90-POSF-2770	100	66		8/14/91				Antifoulant. Substituted amines & butylcatechol in DMF. /100
90-POSF-2788	100	56	300 in 300	8/3/92	440	2688	2/22/93	Stabilizer. Amine substituted resin. / 85-130 mg/L.
					542	2602		
					491	2645	Avg.	
90-POSF-2771	11	101		8/26/91				AO/ disp. Anhydride / polyamine product + solv. 12mg/L
		70		8/26/91				
90-POSF-2772	25	53	300 in 210	8/25/92	734	652	2/22/93	AO / Disp. Imide & acrylate polymer in aro/alcohol. 12mg/L
					867	811		
					801	732	Avg.	
90-POSF-2773	25	45	0 in 300	8/14/92	659	412	1/11/93	AO / Disp. Amine and acrylic polymers in aro/aliph sol. 12
					782	920		
					721	666	Avg.	
90-POSF-2774	12	262		6/17/91				AO/Disp./MDA. Amino alkylphenolic resins, amine aldehyde
Drum #2	12	38	300 in 63	10/15/92				condensate + solvent. 12 mg/L.
90-POSF-2775	11	101		9/11/91				AO/Disp./MDA. Amino alkylphenolic resins, aminealdehyde
		117		9/11/91				condensate + solvent. 12 mg/L.
90-POSF-2776	12	144		6/15/91				AO/Disp./MDA. Amino alkylphenolic resins, alicyclic

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			HLPS AND ICOT TEST RESULTS					Revised 12/02/93
			HLPS			ICOT		
POSF Number	Conc. mg/L	Carbon ug/cm2	ΔP mm Hg / Min.	Burn Off Date	Blower Tube Carbon, ug	Filter Carbon ug	Burn Off Date	Description / Supplier Recommended Dosage, mg/L
								amine / 12 mg/L.
90-POSF-2777	25	25	300 in 12	8/25/92	561	1118	12/9/92	AO/Disp./MDA. Amino alkylphenolic resins, ethylene
					763	1289		diamine. / 12 mg/L.
					662	1204	Avg.	
90-POSF-2778	25	32	300 in 56	8/25/92	611	847	12/10/92	AO/Disp./MDA. Amino alkylphenolic resins, N heterocycle
					576	646		derivatives. / 12 mg/L.
					594	747	Avg.	
93-POSF-2968	25	40	4 in 300	4/2/93	1271	1672	5/24/93	Experimental dispersant
					1295	1653		
					1283	1663	Avg.	
90-POSF-2737	1000	51	23 in 300	5/29/92				Disp. Anhydride polyamine reaction product in sol. 1000 mg/L.
	300	93	4 in 300	6/26/92	117	467	2/22/93	
					22 (?)	471		
						469	Avg.	
Repeat ICOT using mass flow controller								
	300				103	3580	5/25/93	
					100	4060		
					102	3820	Avg.	
90-POSF-2738	1000	218	300 in 182	5/29/92				Dispersant. Anhydride/polyamine reaction products in sol.
90-POSF-2739	300	28	300 in 150	8/14/92	334	505	12/8/92	Disp. Hi MW imide/aminoalkylphenolic resin/acrylic polymer
					345	482		
					340	494	Avg.	
90-POSF-2736	1000	93	300 in 120	5/29/92				Disp. Alkylaryl sulfonates in aromatic solvent. / 1000 mg/L.
93-POSF-2966	300	20	5 in 300	4/2/93	320	1268	5/24/93	Experimental dispersant
					392	1160		
					356	1214	Avg.	
93-POSF-2975	25	44	7 in 300	3/12/93	1998	1181	5/24/93	Experimental antifoulant
					1312	1247		
					1655	1214	Avg.	
93-POSF-2967	25	128	300 in 240	4/2/93	459	1083	5/24/93	Experimental antifoulant
					453	1117		
					456	1100	Avg.	

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HLPS AND ICOT TEST RESULTS

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		HLPS			ICOT			
POSF Number	Conc. mg/L	Carbon ug/cm2	ΔP mm Hg / Min.	Burn Off Date	Blower Tube Carbon, ug	Filter Carbon ug	Burn Off Date	Description / Supplier Recommended Dosage, mg/L
93-POSF-2957	100	85	300 in 110	7/14/93				Detergent/corrosion inhib. Fatty acid amide acid, mixed alkyl alcohols and fatty diamines in dewaxed heavy paraffinic petroleum distillates.
93-POSF-2958	100	42	0 in 300	7/14/93				Detergent/corrosion inhib./demulsifier. Alkenyl succinimide & kerosene in dewaxed heavy paraffinic petroleum distillates.
90-POSF-2781	25	96		10/30/91				AO (N type). 100% N,N'-di-sec-butyl-p-phenylenediamine + solvent. / 2 - 60 mg/L.
90-POSF-2782	25	106		12/16/91				AO (N type). N-phenyl-N'-sec-butyl-p-phenylenediamine + solvent. / 1 -40 mg/L.
90-POSF-2783	25	112		12/16/91				AO (N type). UOP No. 12P + N,N'-di-sec-butyl-o-phenylene-diamine + solvent. / 2 - 40 mg/L.
92-POSF-2951	25	160	1 in 300	8/25/92	115	1287	1/14/93	Dispersant. High molecular weight amine polymer / 25 mg/L
					667	1288		
					391	1288	Avg.	
92-POSF-2952	25	99	300 in 180	8/14/92	629	2372	1/11/93	AO/Disp. Polyamino polyol in aromatic solvent. / 25 mg/L
Repeat	25	116	300 in 120	8/14/92	774	2069		
					702	2221	Avg.	
90-POSF-2784	25	112		10/18/91				AO (O type). 100% mixed tertiary butylphenols / 4-50 mg/L.
90-POSF-2780	10	27	300 in 30	4/10/92	621	873	12/9/92	MDA. N,N'-disalicylidene-1,2-propanediamine & solvent. / 4-16
					416	875		
					519	874	Avg.	
REFERENCE FUELS								
POSF-2799, JP-TS, A F supplied			HLPS Break Point = 750°F (398.9°C)					
		6		9/27/91	65	586	9/1/92	
		7	1 in 300	2/21/92	61	669	10/5/92	
	Avg:	7			84	474		
					84	607		
					74	584	Avg.	
					12	81	S.D.	
					16%	14%	C.V.	

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			HLPS AND ICOT TEST RESULTS					Revised 12/02/93
			HLPS			ICOT		
POSF Number	Conc. mg/L	Carbon ug/cm2	ΔP mm Hg / Min.	Burn Off Date	Blower Tube Carbon, ug	Filter Carbon ug	Burn Off Date	Description / Supplier Recommended Dosage, mg/L
POSF-2747, Super K-1 (Highly refined)		HLPS Break Point = 630°F (332.2°C)						
JFTOT Unit 654 Break Point = 610°F (321.1°C)		Avg. Break Point = 620°F (326.7°C)						
		4		-	465	1899	9/1/92	
		11		-	743	380	9/4/92	
		6	0 in 300	4/15/92	604	1139	Avg.	
	Avg:	7			197		S.D.	
					33%		C.V.	
Repeat with								
Drum#3					199	IGNITED	10/15/92	
					79	1254		
					51	602		
					57	985		
					97	947	Avg.	
POSF 2827, Jet A-1 Reference Fuel				HLPS Break Point = 510°F (265.5°C)				
		145		6/15/91	3344	1859	9/4/92	Drum #1-HLPS / Drum #2-ICOT
		158	300 in 60	7/15/91	2806	1207	9/4/92	
	Avg:	152			4887	7936	9/1/92	
					1747	2609	9/1/92	
					830	1245	10/19/92	
					3196	2971	Avg.	
Drum #2		45	300 in 180	9/4/92				Drum #2 of POSF-2827 was received on 12/17/91.
Repeats		50	300 in 180	9/4/92				Testing with drum #2 began in January 1992.
		72	300 in 180	9/24/92				WL Drum
	Retest	84	300 in 150	10/15/92				
		45	300 in 210	9/24/92				WL Tank
Drum #3		46	300 in 45	1/14/93	1127	1082	2/22/93	

HLPS AND ICOT TEST RESULTS

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		HLPS			ICOT			
POSF Number	Conc. mg/L	Carbon ug/cm2	ΔP mm Hg / Min.	Burn Off Date	Blower Tube Carbon, ug	Filter Carbon ug	Burn Off Date	Description / Supplier Recommended Dosage, mg/L
New HLPS unit		47	300 in 210	2/10/93	945	481		
					1036	782	Avg.	
Drum #3 repeat					2441	1889	5/20/93	
					1654	1660		
					2048	1775	Avg.	
POSF-2827 Break Point on Drum #3: 540°F (282°C)								
POSF 2922, Ashland Jet A, mildly hydrotreated		Break Point: 530°F (277°C)						
		18	6 in 300	4/2/93	8340	23500	5/25/93	
					7390	19600		
					7865	21550	Avg.	
POSF 2926, Shell Oil Jet A		Break Point: 550°F (288°C)						
		24	5 in 300	8/3/92	2638	IGNITED	10/15/92	
Repeat		45	140 in 300	4/2/93	3066	IGNITED		
Repeat		41	0 in 300	4/14/93	1849	IGNITED		
					1821	IGNITED		
					2713	1879		
					2417		Avg.	
POSF 2928, Exxon Jet A with 15% hydrocracked stock.			Break Point 535 F (288 C)					
		37	256 in 300	8/3/92	7290	4090	5/25/93	
Repeat		36	300 in 180	4/2/93	*	4000		* Tube data missing. ?
						4045	Avg.	
POSF 2934, Alaska JP-8 (JET A50: -50°F freeze pt.)								
		121	300 in 60	6/16/93	863	1950	6/16/93	
					1110	2290		

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POSF Number	Conc. mg/L	HLPS Carbon ug/cm2	HLPS ΔP mm Hg / Min.	HLPS Burn Off Date	ICOT Blower Tube Carbon, ug	ICOT Filter Carbon ug	ICOT Burn Off Date	Description / Supplier Recommended Dosage, mg/L
					987	2120	Avg.	
POSF-2936, Cincinnati (high TAN)		Break Point: 530°F (277°C)						
		65	300 in 215	4/15/93	2810	2800	6/2/93	
					3100	3300		
					2955	3090	Avg.	
POSF-2959, Mobil MEROX Treated		Break Point: 560°F (293°C)						
		113	1 in 300	4/20/93	7580	802	5/25/93	
					** (6.5)	1040		** Questionable data.
						921	Avg.	
POSF-2963, NAWC T3 Nozzel Fuel (50 ppb Cu)								
		Plugged	>300 in 60	11/11/93				*The 0.45um filter at the fuel reservior exit was plugged.
Retest without reservoir filter		153	>300 in 46	12/2/93				
POSF-2976, 'New' JPTS								
		6	0 in 300	12/2/93				
POSF-2980, Marathon Oil Co. MEROX Treated		Break Point: 550°F (288°C)						
		52	13 in 300	11/11/93				
POSF-2985, JP-5 (High Nitrogen content)								
		127	300 in 30	11/11/93				
Candidate Additive Experimental P&W Blends								
POSF 2881 + 2786	25+11	9	300 in 25	4/3/92				
POSF 2881 + 2786	25+11	9	300 in 7	4/24/92				

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		HLPS			ICOT			
POSF Number	Conc. mg/L	Carbon ug/cm2	ΔP mm Hg / Min.	Burn Off Date	Blower Tube Carbon, ug	Filter Carbon ug	Burn Off Date	Description / Supplier Recommended Dosage, mg/L
POSF 2881 + 2913	25+5	52	300 in 120	3/27/92				
POSF 2881 + 2913	25+5	11	2 in 300	4/3/92				
POSF 2881 + 2913	25+5	15	165 in 300	4/15/92				
POSF 2881 + 2913	25+5	14	300 in 75	4/24/92				
POSF 2881 + 2913	25+5	11*	6 in 300	5/29/92				* Note: Single batch of blended additives used.
POSF 2881 + 2913	25+5	19*	300 in 270	5/29/92				
POSF 2881 + 2912 **	25 + 5		300 in 11	7/16/92				** Note: No carbon analysis based on delta P result.
POSF 2881 + 2914	25+5	54	300 in 33	6/26/92				
POSF 2881 + 2759	25+1000	1504	11 in 300	5/29/92				
POSF 2843 + 2786	25+11	16	19 in 300	1/17/92				
POSF 2843 + 2786	12+11	22	5 in 300	1/17/92				
POSF 2843 + 2914	25+5	22	300 in 240	4/24/92				
POSF 2843 + 2914	25+5	20	300 in 300	8/3/92				
POSF 2843 + 2904	25+10	18	300 in 30	2/21/92				
POSF 2843 + 2904 + 2913	25+10+5	21	8 in 300	3/11/92				
POSF 2843 + 2913	25+5	27	9 in 300	3/11/92				
POSF 2843 + 2913	25+5	21	1 in 300	4/24/92				
POSF 2843 + 2913	25+5	19	4 in 300	8/3/92				
POSF 2843 + 2912	25+5	10	Line Plug	8/4/92				Flow stopped 2 hours into run - test terminated.
POSF 2843 + 2894	25+25	12	5 in 300	11/4/92				
POSF 2843 + 2730	25+5	16	5 in 300	11/4/92				
POSF 2786 + 2856	11+100	44		9/24/91				
Super K-1 + POSF 2904	10	17		11/15/91				
POSF 2851 + 2904 + 2786	23+10+11	23		11/15/91				
POSF 2894 + 2727	100+300	65	300 in 180	12/10/92	71	431	12/7/92	
					65	505		
					68	468	Avg.	
Repeat	100+300	69	4 in 300	3/12/93	250	393	2/22/93	
					317	*		* Instrument malfunction

HLPS AND ICOT TEST RESULTS

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		HLPS			ICOT			
POSF Number	Conc. mg/L	Carbon ug/cm2	ΔP mm Hg / Min.	Burn Off Date	Blower Tube Carbon, ug	Filter Carbon ug	Burn Off Date	Description / Supplier Recommended Dosage, mg/L
					284		Avg.	
Repeat ICOT using mass flow controller.								
	100+300				41	414	5/25/93	
					60			
					16	449		
					39		Avg.	
POSF 2894 +2950	100+600	15	0 in 300	3/12/93	249	*	2/5/93	* Instrument malfunction
					252	328		
					251		Avg.	
Repeat ICOT using mass flow controller.								
	100+600				547	705	5/25/93	
					449	679		
					498	692	Avg.	
POSF 2894 + 2727 + 2904	100+300+10	57	3 in 300	3/12/93	22	2405	2/22/93	
					27	1323		
					25	1864	Avg.	
POSF 2894+2787	100+10	17	2 in 300	3/12/93	89	37	2/5/93	
					89	203		
					89	120	Avg.	
Repeat I COT using mass flow controller.								
	100+10				1010	874	5/25/93	
					1220	972		
					1115	923	Avg.	
POSF 2894+2787+2790	100+10+100	114	6 in 300	3/12/93	118	659	2/22/93	
					256	579		

			HLPS AND ICOT TEST RESULTS						Revised 12/02/93
			HLPS			ICOT			
POSF Number	Conc. mg/L	Carbon ug/cm2	ΔP mm Hg / Min.	Burn Off Date	Blower Tube Carbon, ug	Filter Carbon ug	Burn Off Date		Description / Supplier Recommended Dosage, mg/L
					187	619	Avg.		
POSF 2894+ 2727 + 2904 + 2856									
	100+300+10+25	58	5 in 300	3/12/93	41	1052	2/22/93		
					42	1404			
					42	1228	Avg.		
Exper. Conc. Blends from Betz Chemical									
70% POSF 2894 + 30% 2787	100	46	4 in 300	4/2/93	107	1227	5/24/93		
					679	1591			
					?	1409	Avg.		
70% 2894+20% 2787+10% 2790	100	17	96 in 300	4/2/93	869	1367	5/24/93		
					843	1375			
					856	1371	Avg.		
Affect of DuPont 2786 in Reference Fuels									
POSF 2827 Jet A-1 Ref. Fuel + 2786	11	30	0 in 300	6/26/92	929	1182	5/20/93		
					795	1070			
					862	1126	Avg.		
POSF 2926 + 2786	11	36	0 in 300	4/26/93	5240	2550	6/8/93		
					3490	1290			
					4365	1920	Avg.		
POSF 2928 + 2786	11	23	0 in 300	4/26/93	5520	2510	6/8/93		

HLPS AND ICOT TEST RESULTS

Revised 12/02/93

POSF Number	Conc. mg/L	HLPS Carbon ug/cm2	HLPS ΔP mm Hg / Min.	HLPS Burn Off Date	ICOT Blower Tube Carbon, ug	ICOT Filter Carbon ug	ICOT Burn Off Date	Description / Supplier Recommended Dosage, mg/L
					5280	2850		
					5400	2680	Avg.	
POSF 2922 + 2786	11	8	0 in 300	4/26/93	4720	13400	6/11/93	
					2990	15600		
					3855	14500	Avg.	
POSF 2934 + 2786	11				669	2230	6/11/93	
					779	1400		
					724	1815	Avg.	
POSF 2936 + 2786	11	29	0 in 300	4/26/93	737	1850	6/3/93	
					866	1830		
					802	1840	Avg.	
POSF 2959 + 2786	11	20	0 in 300	4/26/93	378	279	6/11/93	
					388	303		
					383	291	Avg.	
Affect of POSF 2894 in Reference Fuels								
POSF 2827 Jet A-1 Ref. Fuel + 2894	100	16	2 in 300	Average	1660	1320	1/13/93	
					2110	942		
					1885	1131	Avg.	
POSF 2926 + 2894	100	25	0 in 300	4/14/93	8570	1350	6/8/93	
					7520	1620		
					8045	1485	Avg.	
POSF 2928 + 2894	100	23	0 in 300	4/14/93	5420	2350	6/8/93	
					9120	1820		
					7270	2085	Avg.	

APPENDIX A: APPA_FIN.XLS

			HLPS AND ICOT TEST RESULTS					Revised 12/02/93
			HLPS			ICOT		
POSF Number	Conc. mg/L	Carbon ug/cm2	ΔP mm Hg / Min.	Burn Off Date	Blower Tube Carbon, ug	Filter Carbon ug	Burn Off Date	Description / Supplier Recommended Dosage, mg/L
POSF 2922 + 2894	100	14	0 in 300	4/14/93	4140	13800	6/11/93	
					5920	2830		
					5030		Avg.	
POSF 2934 + 2894	100	180	1 in 300	6/16/93	93	2640	6/11/93	
					6050	2040		
						2340	Avg.	
POSF 2936 + 2894	100	32	0 in 300	4/20/93	3140	3550	6/3/93	
					2770	3250		
					2955	3400	Avg.	
POSF 2959 + 2894	100	30	0 in 300	4/20/93	956	301	6/11/93	
					709	276		
					833	289	Avg.	
AFFECT OF JP8+100 CANDIDATE ADDITIVES ON POSF 2827 JET A-1 REF. FUEL CONTAINING ALL REQUIRED AND OPTIONAL MIL. SPEC. ADDITIVES (MSA)*.								
POSF 2827+MSA*								
POSF 2827+ MSA + 2894	100							
POSF 2827+MSA+ 2894+ 2843	100+25							

*** MSA package components used for these tests:**

Antioxidant (POSF 2851), 24 mg/L.
Antistatic (DuPont Stadis 450), 150 to 600 pS/m.
Corrosion Inhibitor (DuPont DCI 4A), 24 ppm.

APPENDIX A: APPA_FIN.XLS

HLPS AND ICOT TEST RESULTS

Revised 12/02/93

POSF Number	Conc. mg/L	HLPS Carbon ug/cm2	HLPS ΔP mm Hg / Min.	HLPS Burn Off Date	ICOT Blower Tube Carbon, ug	ICOT Filter Carbon ug	ICOT Burn Off Date	Description / Supplier Recommended Dosage, mg/L
Fuel System Icing Inhibitor (Diethylene glycol monomethyl ether), 0.15 volume %.								
SPECIAL INVESTIGATIONS								
POSF-2893, (WL 1/92)		6	300 in 285	2/21/92				
		4	4 in 300	3/27/92				
POSF-2827 + Stressed Super K-1: TAN of 0.015		77	300 in 180	7/1/92				
POSF-2827 + Stressed Super K-1: TAN of 0.03		75	300 in 180	7/1/92				
HLPS 17-MICRON FILTER EXPERIMENT								
POSF 2881 + 2913	25+5	12	23 in 300	8/4/92				The 17 micron filter from test #1 was cleaned with trisolvent,
	25+5	10	300 in 1	8/4/92				vacuum flushed in reverse direction to fuel flow and dried
								prior to use in test #2.

MISC. NOTES:

1. Candidate additive inventory now numbers 162.
2. JP-TS is a blend of:
Isopar H
Varsol 1 (soddard solvent or mineral spirits), IBP 159C; EP 202C
LOPS (low odor parafinic solvent) aka Turbo Fuel A

3. Additive Incompatibility:
POSF 2871 must be heated to get into solution; over night drops out of solution. Hazy swirls.
POSF 2855 plugged filter 2 hours into test.
POSF 2866 Unable to get into solution after heating at 120°F and stirring over night .
POSF 2876 blocked fuel line 1 hour into test.
POSF 2881 rapid delta P increase. Variable delta P with 2913 & 2912 . Insoluble precipate when blended with 2759 and 2899.

		MTP Tests								Revised 03/26/92		
										All Data From All Tests		
POSF		*Conc.*		*Test*		*50 mL Samples, µg carbon*				***Filter***		*std*
No.	*Description*	*(mg/L)*	*Date*	*No.*	*1*	*2*	*3*	*4*	*5*	***Avg.***	*Avg.*	*dev.*
JP-TS	10 mg/L 2904 +	0	7/24/91	1	1571	1619	1638	1796	1896	**1704**		
Exxon	23 mg/L 2851 +		8/02/91	2	3632	3670	3755	4109	3790	**3791**		
	11 mg/l 2786			3	2947	2962	3057	2927	2908	**2960**	2818	897
				4	2799	2790	3001			**2863**	Not Prefiltered	
91-2799	Upper Limit	0	8/09/91	1	3135	2847	2480	3354	3370	**3037**		
			8/09/91	2	3792	3676	3968	3761	4116	**3863**	3450	516
90-2747	Highly Refined	0	8/12/91	1	3133	2918	3119	2888	2879	**2987**		
			8/14/91	2	5629	5865	5786	5698	6463	**5888**	4438	1547
				3	4874							
	N2 Over Pressure	0	9/06/91	1	374	357	344	340		**354**		
	No Over Pressure	0	9/20/91	1	706	694	709	730	824	**733**		
90-2786	SOA	11	7/24/91	1		8774	8363	7149	7258	**7886**		
			8/02/91	2	8827	9236	9943	8800	8996	**9160**		
			8/12/91	3	7336	7405	7156	7220	7378	**7299**	8132	956
	SOA	50	9/20/91	1	9443	8983	8441	10070	9332	**9254**		
		100	9/24/91	1	8375	7725	5894	6155	6091	**6848**		
90-2748	Extender/Stabilizer	200		1	10610	10840				**10725**	Not Prefiltered	
90-2753	N2/O2 Type AO	25		1	7520	9012				**8153**	Not Prefiltered	
90-2761	N2 AO	25	7/25/91	1	7248	6077	5147	4539	4483	**5499**		
				2	6304	5977	5327	4750	4716	**5415**	5457	915
				3	6774	5838	6500			**6371**	Not Prefiltered	
90-2726	Det./Disp.	1000		1	8773	6190	4930	5098	15170	Formed Sludge		
90-2776	AO/Det./Disp./	12		1	8382	9227				**8805**	Not Prefiltered	
91-2827	Additive Free	0	7/23/91	1	8957	8334	7276	7225	7408	**7840**		
				2	7004	6643	6200	6107	6466	**6484**	7162	912
				3	7474	6968				**7221**	Not Prefiltered	
	N2 Over Pressure	0	9/06/91	1	748	718	762			**743**		
	No Over Pressure	0	9/23/91	1	372	347	462	350	361	**378**		
90-2774	AO/Disp./MD	12		1	9838	10260				**10049**	Not Prefiltered	
90-2744	Det./Disp.	1000		1	14000	13720				**13860**	Not Prefiltered	

Notes:

MTP Test Conditions: Prefiltered fuel/Air spraged/300F°/3 HRS./200psi air/No solvent rinse

Disp. = Dispersant; Det.=Detergent; AO= Antioxidant; MD=Metal Deactivator

	FUEL REACTOR TESTS						Revised 4/14/92		
POSF No.	Description	Conc. (mg/L)	BURN OFF Date	Test No.	Carbon ug	Avg. of Runs	Range	sd	r (sd/x)
91-2799	Upper Limit	0	12/6/91	1	242				
			12/6/91	2	216	229	26	18	
			4/9/92	3	155				
			4/9/92	4	164	160	9	6	
91-2827	Additive Free	0	12/6/91	1	545				
			12/16/91	2	433				
			12/16/91	3	553				
			12/16/91	4	474	501	120	58	
			4/9/92	5	562				
			4/9/92	6	570	566	8	6	
2786in 2747		11	1/16/92	1	250				
			1/16/92	2	242				
			1/16/92	3	258				
			1/16/92	4	242	248	16	8	
90-2747	Highly Processed	0	1/16/92	1	260				
			1/16/92	2	278				
			1/16/92	3	285				
			1/16/92	4	252	269	33	15	
			4/9/92	5	181				
			4/9/92	6	168	175	13	9	
90-2761	N2 Type AO	25	2/7/92	1	496				
			2/7/92	2	398	447	98	69	
			2/7/92	3	551				
			2/7/92	4	483	517	68	48	
90-2786	SOA	11	2/7/92	1	783				
			2/7/92	2	493				
			2/7/92	3	453				
			2/7/92	4	441	543	342	162	
			4/9/92	5	787				
			4/9/92	6	815	801	28	20	
91-2841	N2/O2 AO	25	3/4/92	1	223				
			3/4/92	4	373	298	150	106	
91-9843	O2 AO	25	3/4/92	3	192				
			3/4/92	4	167	180	25	18	
Test Conditions: 6-min. air sparge; 200 psi air; 300F; 3 hrs.; 60 mL sample; COS bath									

	FUEL REACTOR TESTS						Revised 4/14/92		
POSF No.	*Description*	*Conc. (mg/L)*	*BURN OFF Date*	*Test No.*	**Carbon ug**	*Avg. of Runs*	*Range*	sd	r (sd/x)
90-2774	AO/Disp/MD	25	3/4/92	2	234				
			3/4/92	3	274	254	40	28	
91-2881	N2 AO	25	3/4/92	1	486				
			3/4/92	2	250	368	236	167	
2[illegible]36	AO/Dispersant	25/11	4/2/92	1	279				
			4/2/92	2	229	254	50	35	
			4/9/92	3	269				
			4/9/92	4	296	283	27	19	
2881+2786	AO/Dispersant	25/11	4/2/92	1	325				
			4/2/92	2	283	304	42	30	
91-2385	N2 AO		4/9/92	1	429				
			4/9/92	2	280	354	149	105	
91-2872	N2/O2 AO		4/9/92	1	348				
			4/9/92	2	343	345	5	4	