SERVICE BULLETIN
No. 982

BIOBOR® JF AVIATION
Fuel Microbiocide

Instructions for use...

Biobor®JF for Aviation Fuel

The Worldwide Standard Since 1965

A Guide to understanding, recognizing and treating microbial infestation in aviation fuel.

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HAMMONDS FUEL ADDITIVES, INC.

INTRODUCTION

This service bulletin is an aid to understanding, recognizing and treating microbial contamination in aviation jet fuel using Biobor®JF. It was the first fuel biocide approved for use in aviation fuels and is a proprietary chemisty designed to address the unique issues encountered in aircraft and aviation fuel storage systems. It is vital to have an understanding of how microbes exist in jet fuel and how their presence can cause devastating damage to fuel, aircraft and fuel handling systems. Costs related for cleaning or repairing aircraft and the lost revenue associated with downtime due to microbial contamination demand that fuel tanks be kept free of contamination through regular monitoring and treatment with an approved biocide. Biobor®JF is simple to use and is compatible with a wide variety of fuel system parts, top coatings, sealants and elastomeric materials. Biobor®JF does not affect fuel performance and is proven to add lubricity to jet fuel, providing additional protection and reduced wear to fuel delivery components.

Clean, dry fuel is an imperative. Take care reading this service bulletin. Pay particular attention to the section on blending before attempting to use Biobor®JF. This product is a special formulation of glycol borates designed for maximum biocidal effectiveness. It works in both the water and fuel phase to kill microbial growth. Biobor®JF is authorized by the FAA, and IATA, recommended by both airframe manufacturers and engine manufacturers to be used for both preventative maintenance and curative for killing microbial growth when needed.

A complete discussion follows for proper handling and use. Should more information be needed, contact a technical service representative at Hammonds Fuel Additives, Inc. Office phone numbers and addresses are listed at the end of this bulletin.

Biobor®JF is registered with EPA as a pesticide (EPA Reg. No. 65217-1).
Biobor®JF is recognized by a military specification number (MIL-S-53021).
Biobor® is recognized by ASTM, FAA and IATA.

FUEL CONTAMINATION IN AIRCRAFT

Occurrence of Microbial Contamination in Aircraft

Several forms of microbes can survive and multiply in hydrocarbon fuel systems. Microbial growth is known to occur in all components of the fuel handling system including storage tanks, pumps, filters/separators, refuelers and delivery lines as well as aircraft fuel tanks. Under the right conditions, they form colonies and create biomass. Microbial biomass can be slimy or sticky often black, green or brown in color, although it may appear in a variety of colors. Although microbes can exist throughout the fuel, they generally require water to grow and multiply. One common area where water accumulates is the tank sump. While this tends to be a primary area of concern where free water can be found, aircraft fuel tanks have numerous structures and irregular surfaces prone to condensation or free water. Common areas include spars, rivets, welds or pockets where water can accumulate as it settles. These low or trapped areas can hold enough water to support biological life. A 1 millimeter drop of water can support 1 million microbes, enough to lead to a major contamination problem. Since fuel is agitated during fueling or recirculation during flight, any microbes present will spread throughout the tank where they cling to walls and structures throughout the fuel system. **It is important to realize that microbes can exist in the fuel, free water and in condensation throughout the fuel system.**

There are a host of common microorganisms commonly found in fuel systems. It grows rapidly under widely varying conditions, needing only trace amounts of water and a food source, which fuel supplies, in order to grow and multiply. Microbes produce biomass sludge and acidic byproducts. These byproducts corrode fuel tank linings and hoses. It pits metal components form holes and weaknesses. Corrosion in a "wet wing" fuel tank degrades the quality and strength of every surface contacting the fuel. Since structures in the fuel tank are structural components of the wing and airframe, corrosion and weakening of the metal components can ultimately compromise the structural integrity of the aircraft and threaten the safety of all aboard. In addition to structural weakening, seals, coatings and elastomers can also be damaged.

Fuel tank gauging systems can also be affected by microbial growth. Slime and corrosion on fuel probes can deliver false or erratic data to instruments. Biomass can form from microbial colonies and dead microbes following treatment both in the aircraft and fuel system filter/separators. Fuel starvation is dangerous during any segment of flight, but is even more hazardous during times of high fuel consumption such as demand for full power during takeoff. It is at this critical time of flight that an aircraft is most vulnerable to variations or total loss of power.

Detection of Microbial Contamination

Evidence of contamination can be found on filters, tank surfaces, and fuel lines often forming a sticky mass. Filter/separators may indicate accumulations of microbes by registering high differential pressure across the filter. As infestation grows, the fuel may develop a smell of sulfur, similar to rotten eggs. Where there is no clear evidence, but contamination is suspected, there are methods for testing fuel for the presence of microbial growth. A number of simple field test kits are available that can both qualify and quantify the presence of microbes. The Hammonds HumBug Detector Kit is a simple test kit that includes a sterile vial of nutrients that support rapid microbial growth. A sample of the fuel and or fuel water interface is collected from the tank and injected into the vile. A reagent chemically reacts with drawn fuel sample, turning a shade of red when microbes are present (the darker the red color and faster it reacts, the higher level of contamination). Although this kit can indicate the presence and severity of the infestation, it is not designed as a quantitative test. Since any level of microbial presence is potentially dangerous, the kit is designed to indicate their presence. Other tests can, with some accuracy, reflect the colony size of a given sample.

Whenever fuel tank areas are opened for a maintenance inspection, a visual examination should be made to determine the presence of microbial contamination in the form of slimes or biomass on interior surfaces especially the sump area where water collects and growth can be a problem. Water, routinely drawn from the sump or water bottom, should also be inspected closely for discoloration, odor and particulates. Be certain to look at areas where sealants meet spars, frames or other structures including rivet heads. Areas the size of a rivet can collect enough water above the sump area of a tank to support microbial life. Microbial growth can be difficult to abate due to inaccessible areas or places difficult to inspect. Sump samples can show no presence of microbial growth when water is trapped in other inaccessible areas. Samples taken are not necessarily representative of the entire tank. **If microbial growth is indicated in the sump, the likelihood of microbes throughout the fuel system is much greater. It is extremely important to use a dual-phase biocide such as Biobor®JF since it will treat the entire tank including the sump**.

Erratic readings from fuel quantity probes may be due to an accumulation of biomass deposits. Physical cleaning of the fuel probes can reduce the problem temporarily. Without proper biocide treatment, microbial growth will continue resulting in faulty readings, corrosion and fuel system damage.

Positive findings of microbial contamination demand immediate action in order to prevent further damage.

Prevention of Microbial Contamination

Microbial contamination in fuels can be alleviated by a two-step procedure:

1. Use Biobor®JF following the instructions given below.
2. Proper maintenance of the fuel system. The effectiveness of any biocide will be reduced if microbial debris and water are allowed to remain in the tank after cleaning and treatment. Proper maintenance therefore requires regular removal of accumulated water bottoms and drainage of sump areas in addition to proper filtering to remove debris. Filters and screens should be inspected regularly. Storage tanks must be included in regular cleaning and inspection schedules. In some instances, good housekeeping may be all that is needed to prevent fungal growth. Contamination occurs very easily, and even the best maintained system may require the use of Biobor®JF as a part of regular maintenance in order to provide a clean, safe fuel system.

INSTRUCTIONS FOR USE OF BIOBOR®JF

General Considerations

Prepare the system before using Biobor®JF by checking the condition of the entire system. If microbial contamination has already occurred, there may be damage that should be repaired. In badly contaminated systems, as Biobor®JF kills the microbes; water, chemical and physical debris can be released that may further damage or clog the fuel system. **Before adding Biobor®JF, drain all water bottoms completely.**

When adding Biobor®JF, consult the dosage charts (Tables II, III, and IV), or calculate the amount of Biobor®JF necessary to treat the fuel. For contaminated systems, or tanks prone to microbial attack, use the higher "shock" treatment level. This is calculated at 270 ppm by weight Biobor®JF in fuel, or approximately one gallon of Biobor®JF for 4,766 gallons of turbine fuel (210 ppmv). For jet fuel, a density of 6.7 pounds per gallon is used as a basis for the calculation. Density of Biobor®JF is 8.75 pounds per gallon.

For maintenance in new or previously treated tanks, a level of 135 ppmw by weight Biobor®JF or approximately one gallon Biobor®JF in 9,532 gallons of turbine fuel may be used (105 ppmv). Exact usage will vary due to variations in weather, movement of fuel and aircraft type. If contamination occurs, use the 270 ppmw addition. In no instance should Biobor®JF be used at more than 270 ppm in the fuel, as this would exceed certification test standards. Using more Biobor®JF than the recommended dosage does not add to its effectiveness. Also, consult your aircraft manufacturers' operations manual for recommended frequency of usage.

When using Biobor®JF, check the filters frequently at first. Dying microorganisms and the associated biomass particulates will filter out. The slime itself may come off walls and structures as the microbes are killed. Once Biobor®JF is applied to fuel, it begins to work immediately. However, when large infestations exist, it is important to allow sufficient time for the Biobor®JF to provide a thorough kill. Biobor®JF must penetrate the exterior walls and membranes of each microbial cell. Since the cells collect together in a biomass mat, the breaking down of the mat must occur before all cells are fully exposed to the fuel containing Biobor®JF. A concern is that Biobor®JF treated fuel in a contaminated tank will begin to break up large mats of growth into smaller ones which, once dislodged, could cause filter or line plugging. It is important that treated fuel be allowed to kill the infestation completely. When large, visible infestations exist, once killed, biomass and particulate matter which may have been trapped in large mats of microbial growth will need to be removed manually or through filtration. Also, tanks that are not completely filled with treated fuel may not get protection above the fuel level. Therefore it is recommended that Biobor®JF treated fuel be used to fill tanks to capacity in order to ensure total sterilization. Often, in cases where infestation reoccurs, it is due to failure to sterilize the entire tank previously.

1. Blending Biobor®JF with consideration to water.

Turbine fuel, by its nature, always contains some water. ASTM D1655 specification allows up to 30 ppm of free water in the fuel to remain within specification. There are several opportunities for water to enter the fuel during distribution prior to the aircraft. Condensation generated in above and below ground tanks, rain from floating roof tanks and residual water from transport trucks are examples of how water can get in fuel, and in the tanks of an aircraft. After an aircraft receives fuel, there is an opportunity for condensation to form during each flight cycle. Super cold temperatures at altitude and very hot temperatures on the ground create the perfect conditions for condensing water from the atmosphere. Always be sure fuel has been properly maintained and filtered to remove water and debris and all water bottoms or sumps are drained completely before treating. Although Biobor®JF works both in the fuel and water phase of fuel; it should not be added directly to the sump or water bottom of a fuel tank. Biobor®JF's chemistry was designed to move through the fuel and properly partition into both the fuel and water phase providing an effective microbial kill. **Mass water contamination events must be avoided. In order for Biobor®JF to function as designed, water bottoms and sumps must be drained prior to application and regular sump drainage should continue post treatment.**

Drain all sumps before treating!

Any fuel additive, regardless of type, should be metered accurately and blended thoroughly in the fuel in order to optimize performance. Since Biobor®JF is essentially a dual phase biocide, and since the additized fuel should be distributed to all parts of the fuel system, proportionate-to-flow injection is highly recommended.

2. Methods of blending

A. Metered Injection: Hammonds offers a fluid powered injector that automatically injects and blends the additive thoroughly as fuel passes through the system. Energy in the moving fuel turns a fluid motor which in turn powers an injection pump delivering a continuous, even flow of additive throughout the fueling process. Injection takes place upstream of the fluid motor which provides complete and consistent blending of the additive. Using this method, every gallon of fuel receives the specified dose of additive making it possible to distribute the treated fuel throughout the aircraft. Complete dispersion is obtained immediately, which is especially important in wing tanks with baffles and in aircraft that cannot be re-circulated to promote mixing. This type of injector can be temporarily connected in-line between the fuel truck or hydrant system and the aircraft. Other configurations can be installed on refuelers and on fuel farms. These systems can be configured to inject proportionately at 135 ppmw or 270 ppmw or to inject an entire treatment in a partial load of fuel in order to facilitate blending.

B. Splash/Over wing: The other method of blending additive is referred to as "over wing" blending and this method should be used only when metered blending is not possible. **Using this method when on-board circulation is not possible can lead to chronic under treatment in some areas of the fuel tank. This will result in a lack of fungal control in those neglected areas.** With this method, additive is typically blended with a small amount of fuel and that mixture is slowly added to the tank through an over wing fueling port, or in some cases, an inspection port in the wing. Ideally, this procedure takes place as the aircraft is fueled which aids in blending the additive with fuel. Once the fuel is in the aircraft, the fuel is circulated for a period of time helping to distribute the additized fuel throughout the fuel system. Since micro-water bottoms can exist throughout the aircraft, it is imperative that additive is circulated thoroughly reaching every part of the fuel system. Remember to always check your AMM for recommended practices.

C: Additive blending with a refueler outside the aircraft.

For optimum performance of a biocide, there is only one way to insure that the proper amount of additive will be dispersed throughout the aircraft. After the sumps have been drained, the entire contents of the aircraft should be de-fueled into an empty refueler. At this point, if there is evidence of gross infestation, inspection of the fuel tanks would be advisable. This inspection would dictate further cleaning and/or maintenance procedures on the fuel tank and internal components. Assuming there are no further actions required to the aircraft, follow these steps in treating the fuel tanks.

1. After the aircraft has been idle for at least 4 hours, drain the water sumps completely. Remember, water settles by gravity at the rate of approximately 12" per hour. This will insure that the majority of suspended water will have time to settle to the sumps.
2. De-fuel the aircraft into an empty refueler with sufficient capacity to hold the entire contents of the aircraft. Caution: Fuel removed from an aircraft must not be co-mingled into storage or any other fuel that is for distribution to other aircraft or customers.
3. Calculate how much additional fuel will be needed to completely fill the aircraft in addition to the fuel in the refueler.
4. Based on the total capacity of the aircraft, calculate how much additive is required for either a maintenance or shock treatment. See Tables II and III for calculating volume.
5. Add the Biobor®JF to the refueler tank based on step #4.
6. Add the additional fuel to the refueler necessary to completely fill the aircraft.
7. Connecting the single point fueling hose to the bottom loading valve of the refueler, re-circulate the fuel on high speed for at least 5 minutes in order to completely mix the Biobor®JF throughout the entire load of fuel.
8. Inject the treated fuel back into the aircraft.
9. Allow aircraft to soak for at least 12 hours, testing the fuel every 8 hours until evidence of living organisms is gone.
10. Assuming there is considerable residue left from a gross infestation, the aircraft should be de-fueled, filtering the fuel as it leaves the aircraft, and then filtering again upon returning the same fuel to the aircraft.
11. If there has been a gross infestation, all filters and screens in the aircraft should be checked before flight resumes.
12. Aircraft manufacturer recommendations for post-cleaning procedures should be followed carefully. Filters may require changing several times as residue is removed from the fuel during consumption. Operators should monitor filters very carefully following any level of infestation and treatment with a biocide.

D. Blending in a partially filled aircraft using an additive injector: Assuming it is not practical to completely drain the aircraft, tanks can be treated with the following procedure.

1. Treat the aircraft when the fuel level is at the lowest possible point.
2. After the aircraft has set idle for at least 4 hours, drain the water sumps completely. Remember, water settles by gravity at the rate of approximately 12" per hour. This will insure that any suspended water in the fuel will have time to settle into the sumps.
3. Using Table II and III, determine how much Biobor®JF is required to treat the entire fuel load of the aircraft when tanks are full.
4. Consult the operator's manual of your additive system and determine the system settings that will be necessary to inject the calculated amount while the remaining capacities of the fuel tanks are loaded through the system.
5. Fuel the aircraft to capacity.
6. Allow the aircraft to set idle for at least 12 hours testing the fuel every 8 hours until evidence of living organisms is gone.
7. Assuming there is considerable residue left from a gross infestation, the aircraft should be de-fueled, filtering the fuel as it leaves the aircraft, and then filtering again upon returning the same fuel to the aircraft.
8. If there has been a gross infestation, all filters and screens in the aircraft should be checked before flight resumes.
9. Aircraft manufacturer recommendations for post-cleaning procedures should be followed carefully. Filters may require changing several times as residue is removed from the fuel during consumption. Operators should monitor filters very carefully following any level of infestation and treatment with a biocide.

E. Blending using over-wing mixing

1. Treat the aircraft when the fuel level is at the lowest possible point.
2. After the aircraft has set idle for at least 4 hours, drain the water sumps completely. Remember, water settles by gravity at the rate of approximately 12" per hour. This will insure that any suspended water in the fuel will have time to settle into the sumps.
3. Using Tables II and III, determine how much Biobor®JF is required to treat **the entire fuel load** of the aircraft when tanks are full.
4. Mix that amount of Biobor®JF in a 5 gallon bucket full of fuel. Blend that mixture thoroughly.
5. **With the bucket grounded to the aircraft** and using the inspection ports or over wing fueling ports in the fuel tanks, pour the mixture in the tanks as the aircraft is being fueled. **Simultaneous fueling and pouring of Biobor®JF in the tank may not be possible using an inspection point as an entry point for the Biobor®JF. Caution: If the aircraft has two fuel tanks, divide the mixture between the two tanks.**
6. After all the Biobor®JF mixture has been poured in the tanks, complete the filling until the aircraft is completely full. Never add Biobor®JF to an empty tank.
7. Using on-board circulating pumps, circulate the fuel from tank-to-tank. This mixing action accomplished by internal pumping is necessary to insure that blended fuel reaches every part of the fuel tanks.
8. Assuming there is considerable residue left form a gross infestation, the aircraft should be de-fueled, filtering the fuel as it leaves the aircraft, and then filtering again upon returning the same fuel to the aircraft.
9. If there has been a gross infestation, all filters and screens in the aircraft should be checked before flight resumes.
10. Aircraft manufacturer recommendations for post-cleaning procedures should be followed carefully. Filters may require changing several times as residue is removed from the fuel during consumption. Operators should monitor filters very carefully following any level of infestation and treatment with a biocide.

3. Storage Tank treatment

Biobor®JF may be added to storage tanks following the same precautions as outlined above. Again, metered injection into the incoming stream of fuel is the preferred method. Water bottoms should be drained prior to treatment. When treating storage tanks, be sure that all aircraft to receive fuel from that tank have approval for Biobor®JF use.

4. Storage and Handling of Biobor®JF containers.

Biobor®JF containers, particularly 55 gallon or 5 gallon drums should be protected from rain water that could collect in the top of the container. Even when the drum or pail is capped securely, changes in ambient temperature can cause a negative pressure in the container, drawing water in through threaded fittings and contaminating the Biobor®JF. Water should never be added directly to Biobor®JF and Biobor®JF should not be added directly to water without being diluted in fuel as with normal treating procedures. Avoid prolonged storage of containers that have been opened, choose a size most suitable to your needs. Before use, clean the lid area of dust and dirt. Discard if product is discolored or contains solids. Do not transfer Biobor®JF to other containers for storage.

Biobor®JF is presently available in 16 ounce, one quart, one gallon, five gallon and fifty-five gallon non-returnable metal drums. 16 ounce Easy Squeeze containers are packaged twelve bottles per case. Quarts are delivered in Easy Squeeze containers packed six per case.

Shelf life of Biobor®JF is 36 months from date of manufacture, indicated by a batch number sticker located on each container.
Contact Hammonds directly for batch number assistance.

TABLE 1

PRODUCT DATA

Chemical Composition	
Active Ingredients	
2,2'-oxybis (4,4,6-trimethyl-1, 3,2-dioxaborinane)	
2,2'-(1-methyltrimethylenedioxy) bis-(4-methyl 1-1, 3, 2-dioxaborinane)	95.0%
Inert Ingredients	
Petroleum Naphtha	4.5%
Inerts	0.5%
Total	100.0%
Boron Content	7.3%
Physical Properties (typical)	
Flash Point, TCC (Tag Closed Cup)	104 + 2°F.
Density	1.05g/cc @ 68°F.
Pour Point	-27°F.
Color (ASTM)	0.5.

TABLE 2

DOSAGE LEVELS

(Fuel = U.S. Gallons)

JET FUEL		SHOCK TREATMENT @270 PPMW		MAINTENANCE LEVEL @135 PPMW	
Lbs.	**Gals.**	**Gals.**	**Fl. Oz.**	**Gal.**	**Fl. Oz.**
670	100	0.02	2.6	0.01	1.3
1,340	200	0.04	5.3	0.02	2.6
2,010	300	0.06	8.0	0.03	4.0
2,680	400	0.08	10.7	0.04	5.3
3,350	500	0.10	13.4	0.05	6.7
6,700	1,000	0.21	26.8	0.10	13.4
13,400	2,000	0.42	53.6	0.21	26.8
16,750	2,500	0.52	67.0	0.26	33.5
33,500	5,000	1.0	134.0	0.52	67.0
67,000	10,000	2.1	268.0	1.04	134.0
134,000	20,000	4.2	536.0	2.09	268.0
335,000	50,000	10.3	1,340.0	5.23	670.0

To determine the fluid ounces of Biobor®JF required to give a concentration of 270 ppmw, multiply pounds of fuel by 0.004 and for 135 ppmw by 0.002.
Density of Jet Fuel:: 1 gallon weighs 6.714 pounds.

TABLE 3

DOSAGE METRIC EQUIVALENTS

TURBINE FUEL* U.S. Gallons	Liters	BIOBOR®JF (270 PPMW)**	BIOBOR®JF (135 PPMW)**
100	378.5	80 ml	40 ml
300	1,135.5	236 ml	118 ml
625	2,365.6	473 ml	236 ml
1,250	4,731.3	946 ml	473 ml

*Assuming fuel density of 0.804g/ml
**Biobor®JF density = 1.05g/ml

TABLE 4

METRIC CONVERSIONS FOR VARIOUS FUELS

SHOCK TREATMENT AT 270 PPMW

FUEL	g/ml	Fuel Density at 15°C / 59°F lbs./gal.	kg/L	oz. of Biobor®JF per 1000 gal. fuel	ml of Biobor®JF per 1000 liters fuel
JP-4	0.760l	6.343	.762	25.37	198.27
Kerosene (Turbine Fuel)	0.8045	6.714	.806	26.86	209.57
Diesel #1	0.8180	6.827	.820	27.31	214.50
Diesel #2	0.8484	7.080	.850	28.32	220.99
Bunker "C"	0.9952	8.305	.997	33.22	259.26

To determine the fluid ounces of Biobor®JF required to give a concentration of 270 ppmw, multiply pounds of fuel by 0.004 and for 135 ppmw by 0.002.

To determine milliliters of Biobor®JF required to give a concentration of 270 ppmw, multiply kilograms of fuel by .26 and for 135 ppmw by .13.

*Computed from fuel densities as surveyed by the American Petroleum Institute.

TABLE 5

COMPATIBILITY WITH FUEL SYSTEM COMPONENTS

Biobor®JF is compatible with:

I. Top Coatings and Sealants

1. Buna-N (EC-7765-R)
2. Polyurethane PR-1560
3. PR-1422 (Thiokol type)
4. PR-703 Products Research Corporation
5. PR-1422 Products Research Corporation
6. PR-9021 Product Research Corporation
7. Pro Seal-719 Coast Pro Seal Company
8. Pro Seal-890 Coast Pro Seal Company
9. Z9-0048 Dow Corning Corporation

I1. Fuel Cell Materials

1.	Estane 580029	B.F. Goodrich
2.	BTC-17-10	Goodyear
3.	BTC-12-2	Goodyear
4.	BTC-49	Goodyear
5.	BTC-54A	Goodyear
6.	BTC-67	Goodyear
7.	BTC-85	Goodyear
8.	BTC-86	Goodyear
9.	10740SR	Firestone
10.	LS-53 Silicone	Dow Corning
11.	MIL R-6865	Precision Components
12.	US-566R/RL	UNIROYAL (nitrile materials)
13.	US-943	INIROYAL (nitrile materials)

III. Metal Alloys

1.	SAE 1010	Steel
2.	AZ92	Magnesium
3.	2024	Aluminum
4.	4015	Aluminum
5.	7178	Aluminum
6.	7075	Aluminum
7.	Cad plated steel	

IV Fuel Tank Gauging Systems

1. Approved by Minneapolis Honeywell
2. Approved by Simmonds Precision Products
3. Approval by Liquidometer Corporation
4. Approval by Consolidated Airborne Systems

Biobor®JF is not compatible with Lexan polycarbonate.
Biobor®JF at full strength may not be compatible with some polymeric materials.
TEFLON is recommended for gaskets and/or O-rings where exposure to neat Biobor®JF is anticipated.

*Testing was done at recommended use dilution or two times use dilution.

Hammonds®

BIOBOR®JF

TABLE 6
A SAMPLE OF COMPANIES WHICH RECOMMEND THE USE OF BIOBOR®JF

–USED BY–

MAJOR AIRLINES

American	Southern Airlines
United Airlines	National Airlines
Delta Airlines	Capital Airways
Northwest	Air Jamaica
Lufthansa	TACA International Airlines
British Airways	Varig Airlines
Air France	Qantas
Iberia	Aerolineas Peruanas
	✓ Plus Others

–RECOMMENDED BY–

AIRFRAME MFG.

Boeing Aircraft	Bell Helicopter
AirBus Industries	Fokker Aircraft Corp.
General Dynamics	Lockheed Aircraft Company
Grumman Aircraft	Sikorsky Helicopter
Beechcraft Aircraft Corp.	British Aerospace Aircraft
LearJet Corporation	McDonnell Douglas Aircraft
de Havilland, Inc.	Saberliner Aircraft Corp.
Gulfstream Aerospace Corp.	Douglas
Dassault Falcon Jet	Cessna
	✓ Plus Others

–RECOMMENDED BY–

TURBINE ENGINE MANUFACTURERS

General Electric Engines	Garrett Aircraft Engines
Rolls Royce Engines	Lycoming Engine Corp.
Pratt & Whitney Engines	Allison Industries
Allied Signal Aerospace	United Aircraft of Canada
	✓ Plus Others

MILITARY APPROVED

MIL-S-53021A

U.S. Air Force	U.S. Coast Guard
U.S. Army	U.S. Merchant Marines
U.S. Navy	U.S. Border Patrol

✓ Plus Multiple Foreign Militaries

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