Advisory Pamphlet

AIRCRAFT FUEL CONTROL

AP-1.1.022A

רשות התעופה האזרחית
Civil Aviation Authority

AOC CERTIFICATION

1. Purpose

This Advisory Pamphlet (AP) alerts the aviation community to the potential hazards of inadvertent mixing or contamination of turbine and piston fuels, and provides recommended fuel control and servicing procedures.

2. Reference Material

2.1. Regulatory Requirements

2.1.1. IANR operation no 241(9).

2.2. Reference Material:

2.2.1. American Petroleum Institute Bulletins, Numbers:

2.2.1.1. 1523 Fourth Edition.

2.2.1.2. 1542 Second Edition.

2.2.1.3. 1581 First Edition.

2.2.2. National Fire Protection Association Pamphlet "Aircraft Fuel Servicing 1975"

2.2.3. American Society for Testing and Materials, "Standard Specification for Aviation Gasolines, D 910-75."

2.3. **Forms** – None

3. Guidance and Procedures

3.1. BACKGROUND.

Since the introduction of jet aircraft fuel, there have been several instances of inadvertent fuelling of piston-powered aircraft with jet fuel. Aviation fuel can only serve its ultimate purpose when the PROPER fuel is delivered into the aircraft as free from contamination as it was the day it left the refinery. Unless care and ATTENTION are given to its handling, servicing, and storage, the many precautions taken in its manufacture and transportation are wasted. Close attention to compatibility of fuel and aircraft as well as faithful adherence to good housekeeping practices, is necessary to prevent possible disaster as well as costly contamination. A review of accidents attributed to fuel problems reveals that many power failures were due to use of improper fuel or careless servicing - fuelling aircraft from poorly filtered tanks, particularly small tanks or drums, improper mixing of fuel additives, improper pre-flight action by the pilot, and storing aircraft with partially filled tanks, etc., which invites condensation and contamination of the fuel. It is well to remember that the consequences of using leaded gasoline in jet engines can be as damaging as the use of jet fuel in reciprocating engines.

3.2. TURBINE (JET) FUEL VERSUS GASOLINE.

3.2.1. Investigation of a malfunctioning reciprocating engine disclosed that it had been inadvertently serviced with jet fuel. Examination of this engine revealed extensive cylinder assembly damage that required complete overhaul. Proper attention to refuelling would have prevented this damage.

3.2.2. Frequency of improper fuelling will diminish if owners, operators, and personnel servicing aircraft maintain vigilance. Should the occasion arise where the tanks in an aircraft are accidentally filled with jet fuel, it is suggested the following procedures be followed:

3.2.2.1. If the engines were not operated subsequent to the refueling with jet fuel, drain the fuel tanks, lines, and system completely. Refill the tanks with the proper grade of aviation gasoline, and run the engines for approximately five minutes.

3.2.2.2. If the engines were operated subsequent to the refueling with jet fuel, investigate any abnormal engine operating conditions such as those related to the fuel mixture and cylinder operating temperatures. In addition, accomplish the following:

3.2.2.2.1. Perform a compression test of all cylinders.

3.2.2.2.2. Completely borescope inspect the interior of cylinders, giving special attention to the combustion chamber and the piston dome.

3.2.2.2.3. Drain the engine oil and check the oil screens.

NOTE: When accomplishing 3.2.2.2.1 & 3.2.2.2.2, and 3.2.2.2.3, further investigate and correct any unsatisfactory condition found.

3.2.2.2.4. Completely drain the fuel tanks and the entire fuel system including the engine carburetor.

3.2.2.2.5. Flush the fuel system and carburetor with gasoline and check for leaks. (6) Fill the fuel tanks with the proper grade of aviation gasoline.

3.2.2.2.6. If the engine inspection was satisfactory, complete an engine run-up check.

3.3. AVIATION GASOLINE GRADES AND COLOUR CODES.

Pilots and refueling personnel should be familiar with aviation gasoline (avgas) grades and respective colour codes in order to assure proper servicing of engines. Three grades of avgas are now produced for civil use; grades 80, 100LL (low lead) and 100. These grades replace 80/87, 91/96, 100/130, and 115/145 avgas.

3.3.1. The Standard Specification for Aviation Gasolines, Specification D 910-75, developed by the American Society for Testing and Materials, established that grade 80 should be red in colour and contain 0.5 milliliters (ml.) maximum of tetraethyl lead per gallon. Grade 100LL is blue in colour and contains 2.0 ml. maximum per gallon. Grade 100 is green in colour and contains 3.0 ml. maximum per gallon (with a probable increase to 4.0 ml. maximum per gallon in the next specification revision). The lead quantity or concentration of lead in aviation gasoline is expressed in terms of milliliters (1/1000 of a liter) per gallon of avgas.

Grades 100LL and 100 represent two aviation gasolines that are identical in antiknock quality but differ in maximum lead content and colour. The colour identifies the difference for those engines that have a low tolerance to lead.

3.3.2. Limited availability of grade 80 in some geographical areas of the country has forced owners/operators to use the next higher grade of avgas. Specific use of higher grades is dependent on the applicable manufacturer's recommendations. Continuous use of higher lead fuels in low compression engines designed for low lead fuels can cause erosion or necking of the exhaust valve stems and spark plug lead fouling.

3.4. MARKING.

3.4.1. Israel Air Navigation Regulations require that aircraft fuel filler openings be marked to show the word "FUEL" and the minimum fuel grade or designation for the engines. In order that these markings retain their effectiveness, regulations also require that they be kept fresh and clean. It follows, therefore, that frequent washing and occasional painting will be necessary to retain clear legibility.

3.4.2. It is equally important that tank vehicles be most conspicuously marked to show the type of fuel carried. It is suggested that the marking be of a colour in sharp contrast to that of the vehicle and in lettering at least 12 inches tall. This marking should be on each side and on the rear of the tank vehicles. Additionally, it is suggested that the tank vehicle hose lines be marked by labels next to the nozzle and every six feet. The label lettering should be at least 3/4 inches in height, be of sharp colour contrast, be permanently attached, and indicate the type of fuel dispersed by that hose. A further suggestion is that the refuelling nozzles be conspicuously marked with the appropriate colour code. This is especially important in that the person doing the refuelling will have the colour coded nozzle in his hands during the process with an additional reminder of the fuel type being dispensed. All of the aforementioned markings should be kept clean, fresh, and clearly legible at all times.

3.5. TRAINING.

Careful instructions in operating procedures should be given to all personnel involved in fuelling. This applies to flight as well as ground personnel. The ground personnel should be thoroughly indoctrinated in the facilities, procedures, equipment, and the types of fuel being dispensed - the flight personnel in procedures and marking with particular emphasis on use of the proper type of fuel. It is further suggested that ALL personnel be retrained periodically with suitable records maintained to reflect the training. Only trained competent personnel should perform fuel servicing.

3.6. WHAT IS FUEL CONTAMINATION?

Fuel is contaminated when it contains any material that was not provided under the fuel specification. This material generally consists of water, rust, sand, dust, microbial growth, and certain additives that are not compatible with the fuel, fuel system materials and engines.

3.7. WHAT CAUSES FUEL CONTAMINATION?

3.7.1. Water.

All aviation fuels absorb moisture from the air and contain water in both suspended particle and liquid form. The amount of suspended particles varies with the temperature of the fuel. Whenever the temperature of the fuel is decreased, some of the suspended particles are drawn out of the solution and slowly fall to the bottom of the tank. Whenever the temperature of the fuel increases, water is drawn from the atmosphere to maintain a saturated solution. Changes in fuel temperature, therefore, result in a continuous accumulation of water. During freezing temperatures, this water may turn to ice, restricting or stopping fuel flow.

3.7.2. Rust.

Pipelines, storage tanks, fuel trucks, and drum containers tend to produce rust that can be carried in the fuel in small size particles. A high degree of filtration is required to remove the liquid water and rust particles from the fuel.

3.7.3. Dust and sand.

The fuel may be contaminated with dust and sand through openings in tanks and from the use of fuel handling equipment that is not clean.

3.7.4. Micro-organisms.

Many types of microbes have been found in unleaded fuels, particularly in the turbine engine fuels. The microbes, which may come from the atmosphere or storage tanks, live at the interface between the fuel and liquid water in the tank. These micro-organisms of bacteria and fungi rapidly multiply and cause serious corrosion in tanks and may clog filters, screens, and fuel metering equipment. The growth and corrosion are particularly serious in the presence of other forms of contamination.

3.7.5. Additives.

Certain oil companies, in developing products to cope with aircraft fuel icing problems, found that their products also checked "bug" growth. These products, known as "biocides," are usually referred to as additives. Some additives may not be compatible with the fuel or the materials in the fuel system and may be harmful to other parts of the engine with which they come in contact. Additives that have not been approved by the manufacturer and CAAI should not be used.

3.8. **FIELD TESTS.**

Three gallons of water were added to the half full fuel tank of a popular make, high wing monoplane. After several minutes, the fuel strainer (gascolator) was checked for water. It was necessary to drain ten liquid ounces of fuel before any water appeared. This is considerably more than most pilots drain when checking for water.
In another test, simulating a tricycle geared model, one gallon of water was added to the half-full fuel tank. It was necessary to

drain more than a quart of fuel before any water appeared.
In both of these tests, about nine ounces of water remained in the fuel tank after the belly drain and the fuel strainer (gascolator) had ceased to show any trace of water. This residual water could only be removed by draining the tank sumps.

3.9. CONTAMINATION CONTROL.

The presence of any contamination in fuel systems is dangerous. Laboratory and field tests have demonstrated that when water was introduced into the gasoline tank, it immediately settled to the bottom. Fuel tanks are constructed with sumps to trap this water. It is practically impossible to drain all water from the tanks through the fuel lines, so it becomes necessary to regularly drain the fuel sumps in order to remove all water from the system. It may be necessary to gently rock the wings of some aircraft while draining the sumps to completely drain all the water. On certain tailwheel type aircraft, raising the tail to level flight attitude may result in additional flow of water to the gascolator or main fuel strainer. If left undrained, the water accumulates and will pass through the fuel line to the engine and may cause the engine to stop operating. The elimination of contaminants from aviation fuel may not be entirely possible, but we can control it by the application of good housekeeping habits.

3.9.1. Servicing.

Storage and dispensing equipment should be kept clean at all times - free from dirt and other foreign matter. Fuel having a "cloudy" appearance or definitely "off-colour" should be suspected of contamination or deterioration and should not be used. When additives are used, it is important that they are dispensed in accordance with the aircraft manufacturer's instructions.

Refueling from drums or cans should be considered as an unsatisfactory operation and one to be avoided whenever possible. All containers of this type are to be regarded with suspicion and the contents carefully inspected, identified, and checked for water and other contamination. Extraordinary precautions are necessary to eliminate the hazards of water and sediment. It is advisable when fuelling from drums to use a 5 micron filtered portable pumping unit, or the best filtering equipment available locally, or, as a last resort, a chamois skin filter and filter funnel.

Infrequently used fuel tanks should have their sumps drained before filling. Agitation action of fuel entering the tank may suspend or entrain liquid water or other contaminants - which can remain suspended for many minutes and may not settle out until after the aircraft is airborne.

3.9.2. Preflight action.

Drain a generous sample of fuel - considerably more than just a trickle - into a transparent container from each of the fuel sumps and from the main fuel strainer or gascolator. (Remember that it was necessary to drain ten ounces in the field tests.) On certain aircraft having fuel tanks located in each wing, positioning of the fuel tank selector valve to the "BOTH ON" position may not adequately drain the system. This is due to the fuel taking the path of least resistance. In this case, the fuel selector valve should be positioned at each tank in turn.

Examine the fuel samples for water and dirt contamination. If present, it will collect at the bottom of the container and should be easily detected. Continue to drain fuel from the contaminated sump until certain the system is clear of all water and dirt.

"The use of quick drain valves in the sumps and gascolator makes it practical to keep tanks free of significant quantities of water and other contaminants."

3.9.3. Postflight.

An effective method to prevent contamination from condensation would be to completely fill the fuel tank at the end of each day's flying. This procedure is practical only on a few types of light aircraft. Generally, the type of aircraft, length of proposed flight, number of passengers, and weight and balance limitations dictate the amount of fuel to be added.

3.9.4. Routine maintenance.

In addition to the preflight and postflight actions, certain precautionary or routine maintenance should be performed on the aircraft at periodic intervals. These precautions include the inspection and cleaning of pertinent fuel tank outlet finger strainers and carburetor screens (filters), and flushing of the carburetor bowl.

3.10. JET FUELS.

Turbine powered aircraft, better known as "jet" or "prop jet," generally use a wide cut gasoline or aviation kerosene as fuel. Basically, the same rules and precautions in handling aviation gasoline apply to the jet fuels. As with gasoline, we are concerned with the matter of cleanliness. Turbine fuels are more dense and have a greater viscosity (resistance to flow) than gasoline. It will hold and retain in suspension impurities such as water, fine particles of rust, and other foreign material. These particles can take from five to ten times as long, or even longer, to settle in kerosene as it does for them to settle in gasoline.

Turbine engine fuel controls and pumps are generally more sensitive than the fuel systems of the piston engine. Their fuel feed and pumping systems must work harder. Tolerances are closer and fuel pressures higher. Fine contaminants may block fuel supply systems and erode critical parts of engine and fuel control systems. Water freezing at high altitudes may plug fuel screens. Because of these, the tolerable contamination levels for jet fuels are much lower than previously considered necessary for aviation gasoline. Even with the same contamination levels, the greater volume of fuel used by turbines results in greater amounts of contaminants being deposited in the turbine engine system.

3.10.1. Test for contamination.

Commercial products to test for fuel contamination are available.

3.10.1.1. Here is a simple test to detect contamination of jet fuel. This procedure has proved to be both effective and inexpensive.

- Obtain an unchipped, spotlessly clean, white enamel bucket (approximately ten quart size).
- Drain about four to five inches of fuel, from the sump to be tested, into the bucket.
- With a clean mixing paddle, stir the fuel into a swirling "tornado shaped" cone. Remove paddle. As the swirling stops, the solid contaminants will gather at the centre of the bucket bottom.
- Add several drops of household red food dye. The dye will mix with water and the solids in the bottom of the bucket. It will not mix with fuel. If no water is present, the dye will settle in the bottom of the bucket.

3.11. CONTAMINATED FUEL.

Normally, upon finding that water or other foreign matter contaminates your fuel, the procedures noted under paragraph 3.9 Contamination Control, should suffice. Should contamination persist, or if there is any doubt about it, your best bet is to have your aircraft fuel system inspected by a qualified person.

3.12. **SUMMARY.**

So that your fuel system won't let you down when you want to stay up - remember:

- Turbine fuels for turbine engines - gasoline of the proper grade for reciprocating engines.
- Use only the fuel recommended by the engine and aircraft manufacturer.
- Don't use additives that have not been approved by CAAI.
- If feasible, keep fuel tanks full. Water condenses on the walls of partially filled tanks and enters the fuel system.
- •Filter all fuel entering the tank.
- Drain fuel sumps regularly.
- Periodically inspect and clean all fuel strainers (screens) and occasionally flush the carburettor bowl as recommended by the aircraft manufacturer.

The best insurance against fuel problems - whether aviation gasoline or jet fuel - is to practice good housekeeping in your routine maintenance and be constantly alert.