Civil Aviation Safety Authority Suriname

CASAS Advisory Pamphlet

Subject: WATER IN AVIATION FUELS

CASAS CAP-009

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WATER IN AVIATION FUELS

INTRODUCTION:

The following is a re-print of FAA Advisory Circular 20-125 and is distributed due to "water contaminated fuel" found during the performance of recent accident investigations involving crop dusting aircraft.

1. PURPOSE. This advisory circular (AC) alerts the aviation community to the potential hazards of water in aviation fuels. In addition, it outlines recommended procedures to prevent, detect, and eliminate water in the fuel systems of aircraft.

2. BACKGROUND. Water in fuel continues to contribute to aircraft incidents and accidents and, at times, fatal accidents. Aviation fuel can only serve its ultimate purpose if it is delivered to the aircraft engines(s) free from water. Care and attention are necessary to keep fuel dry (free of water) during transportation from the refinery, storage at airports, storage in refueling equipment, dispensing from refueling equipment into the aircraft; while in the tanks of an aircraft, and from the aircraft tanks to its engine(s). Accordingly, if all persons involved in fuel handling will accept their responsibility to keep fuel dry, water-in-fuel incidents and accidents can be prevented.

3. SOURCE OF WATER IN AVIATION FUEL.

a. Water can enter an airport fuel system through leaks in underground tanks, leaks in the seals of such items as dome covers, floating roofs, and hatches during rain or snow storms, when equipment is being washed, by marine or surface transport equipment delivering fuel to the airport, and by condensation and precipitation of dissolved water in fuel.

b. Water can enter an aircraft fuel system through leaks in the vents, seals, or poorly fitting fuel caps on filler openings during rain or snow storms or when the aircraft is washed, from refueling system equipment, by condensation and precipitation (especially

when an aircraft has partially filled tanks), and when refueling during rain or snow storms.

4. WATER. Water occurs in aviation fuels in two forms: Dissolved and free.

a. Dissolved Water. All aviation fuels dissolve water in varying amounts depending upon the fuel composition and temperature. Dissolved water in fuel is similar to humidity in air.

(1) Lowering fuel temperatures will cause dissolved water to come out of solution as free water somewhat like fog comes out of air. The creation of free water occurs at a rate of about one part per million per degree Fahrenheit (I ppm/deg. F).

(2) Dissolved water is not a problem for aircraft operation as long as it remains in solution. Dissolved water cannot be removed by filtration but can become free water with temperature change. Once free, it can cause operating problems.

b. Free Water. Any water in excess of that which will dissolve is called free water. Free water can appear either as water slugs (in bulk quantities) or as entrained water.

(1) Water slugs are, as the name implies, a relatively large amount of water appearing in one body or layer. A water slug may be a pint or less or may be measured in gallons depending on the capacity of a fuel tank.

(2) Entrained water is suspended in tiny droplets in the fuel. Individual droplets may or may not be visible to the naked eye, but they can give the fuel a cloudy or hazy appearance depending upon their size and quantity.

(3) When a water slug and fuel are violently agitated (for instance when passing through a pump), entrained water results. Entrained water will settle out in time depending upon the droplet size, specific gravity and viscosity of the fuel and currents within the tank. For this reason, a water haze may be seen in turbine fuel but the haze is seldom seen in aviation gasoline. Entrained water may also be formed by the lowering of the temperature of a fuel saturated with dissolved water. Furthermore, entrained water droplets can join together to form large drops or slugs of free water.

(4) Aircraft engines will tolerate a small amount of free water (30 ppm. is usually considered to be the maximum) if it is in a fine, uniformly dispersed state. The best way to minimize the amount of water entering a system is through inspection and maintenance of equipment and by making certain that only clean and dry fuel is received into storage and delivered into an aircraft.

5. WATER DETECTION. Water can be detected in many ways. Free water, laying in the bottom of underground storage tanks can be discovered by the use of water indicator paste spread along the lower end of a gauge stick or tape bob (allow at least 30 seconds for the paste to react, as its reaction time can be slowed down by other contaminants). When the stick or tape bob is lowered to the bottom of the storage tank, the paste will change color in the presence of water. The highest point of the color change indicates the depth of water present.

a. In above ground tanks and equipment, a sample can be drawn into a container and the free water actually observed. A small amount of liquid vegetable dye is sometimes helpful to outline the free water in a sample. It will mix with and color the water, but is insoluble in fuel.

b. Smaller amounts of entrained water can be detected by testing with a clean and dry clear glass bottle. If fuel is acceptably dry it will appear bright with a fluorescent appearance and will not be cloudy or hazy. The clear and dry bottle test is known as the "clean and bright" test. The fuel is clean when it is clear and is bright when it is dry. The container should be large enough to provide for a test sample of 10 ounces or more.

c. The white bucket test is useful in checking, for water in jet fuel. Obtain an un-chipped, spotlessly clean, white porcelain, enameled, or stainless steel bucket (approximately 10 quart size). Drain about 4 or 5 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 swirling stops, contaminants and water will gather under the vortex at the center of the bucket bottom. Add several drops of household red food dye. The dye will mix with any water in the bottom of the bucket. If no water is present, the dye will settle in the bottom of the bucket.

d. Water sensitive papers are also available that will change color in the presence of water.

e. Water detectors specially made for determining free or entrained water in Jet fuels are available. When a customer or local authority requests a chemical test, the Hydro and Aqua-Glo II detector kits are recommended. The Hydro Kit chemical powder is sensitive to water concentrations down to 30 ppm. The Aqua-Glo II Kit can detect levels of water as low as 1 ppm.

6. RESPONSIBILITY FOR DRY FUEL. The responsibility for maintaining dry fuel should be recognized as a joint responsibility of the aircraft manufacturer, maintenance personnel who work on an aircraft, each person who handles the fuel from the refinery to the aircraft, and the pilot who flies the aircraft. The greatest single danger of water in fuel results from human error that allows fuel contaminated with water to enter an aircraft fuel system or permits an aircraft to be operated before its fuel system is properly checked for water. The possibility of human error can never be eliminated, but it can be minimized through careful design and maintenance of airport fueling facilities and fuel equipment and by good operating procedures, inspections, checks, training, and recurrent training of fuel handling personnel and flight personnel.

a. Manufacturers provide detailed information in the aircraft maintenance manuals related to an aircraft's fuel system. In addition, the manufacturers supply service information in the form of service letters, bulletins, notices, etc., when it is determined, through service experience, that its aircraft fuel system may be improved by some modification or that the service life of its product may be extended by some particular maintenance or repair. Additionally, appropriate Federal Aviation Administration (FAA) issued airworthiness directives should be consulted to determine if required changes by some particular maintenance or repair are necessary. Such information should be

reviewed by maintenance personnel, fuel servicing organizations, and especially the pilots of the aircraft to assure that all precautions and inspections to prevent or eliminate water in fuel are accomplished.

b. Maintenance personnel should consult the manufacturers' maintenance manuals and service information, and airworthiness directives related to the aircraft fuel system for the latest requirements and information when doing maintenance on an aircraft fuel system.

(1) Particular attention should be given to checks for water and to the removal of all water from fuel tank sump drains, fuel system line drains, gascolators, strainers, and filters where drain plugs/caps are provided to check and drain an aircraft system of water. Drain plugs/caps should be removed for checks and properly reinstalled. If quick drains are not installed in places required by an airworthiness directive, recommended by the manufacturer, or at points that can be checked frequently, such information should be brought to the attention of the owner/operator for corrective action.

(2) For airplanes equipped with bladder type fuel cells, the general condition and security of each of the cells and the installation should be inspected to assure that the bladder has not deteriorated or loosened from its mountings. These conditions will cause wrinkles, wells, or depressions to form where water can accumulate, avoid drainage, and eventually, find its way to the engine(s) in flight.

(3) Fuel tank filler openings and attachments should be checked for security, general condition, and sealing. Fuel tank caps should be checked for their general condition, plus security and proper sealing when installed. Fuel tank filler opening scupper drains should be checked for free flow to prevent both the accumulation of water in the tank and the entrance of water into the fuel system.

c. Fuel handling personnel should have procedures to assure that clean and dry fuel is being delivered to the storage system. Daily, weekly, monthly, and other calendar time checks should be made on a continuing basis to assure that the fuel in fixed storage and dispensing units and systems is free of water prior to delivery to an aircraft. Personnel dispensing fuel should be recurrently trained in fuel handling to assure that only clean and dry fuel is dispensed.

d. Flight personnel. The owner/operator of an aircraft should be intimately familiar with the fuel system of the aircraft. This familiarity should include the knowledge of the specific requirements for the prevention, detection, and elimination of water in the aircraft fuel system.

(1) The pilot-in-command has the final responsibility to determine that the aircraft is properly serviced. An important part of the preflight inspection is to drain aircraft fuel tank sumps, reservoirs, gascolators, filters, and other fuel system drains to assure that the fuel supply is free of water. A review of National Transportation Safety Board Briefs of Aircraft Accidents involving 114
accidents due to fuel contaminaton with water occurring between January 7, 1980, and September 11, 1981, showed that the probable cause in 85 of those accidents was ' * 'Pilot-in-Command - Inadequate Preflight Preparation and/or Planning." Since water in

fuel accounts for a major share of fuel quality accidents, pilots should make it a practice to include this check beginning with the next preflight inspection.

(2) The pilot-in-command should also be present during the refueling operation to inspect a sample of the fuel from the dispensing unit prior to fueling the aircraft.

7. WATER REMOVAL/PREVENTION. Water is best removed from jet fuel by passing the fuei through approved filt7a-tion/separation equipment. A two-hour settling period and the use of floating suction to drain fuel from the top of a storage tank are also recommended to help prevent water from being introduced into a fuel system. Water will readily settle-out of aviation gasoline; therefore, filters/separators are not required for water removal, however, they are necessary for removal of solids. The best means to minimize the amount of water entering a fuel system is the inspection and proper maintenance of equipment and the training of ground and flight personnel.

a. Fixed Facilities. A thorough knowledge of the construction, function, operation, and maintenance of each component of each piece of equipment of a fixed facility is recommended for all personnel responsible for its usage**.** A principal factor, which minimizes the amount of water introduced into fixed storage, is receiving only dry fuel.

(1) All storage tank bottoms and filter/separator sumps should be checked for water. Accumulations should be removed before and after each receipt of fuel, after a heavy rainfall, snowfall, daily, or more often when in accordance with the fuel distributor's instructions.

(2) Filter elements are required to be replaced whenever the differential pressure across the filter or filter/separator drops below the minimum specified by the manufacturer, when no pressure drop is indicated, or when the calendar time for change is due.

(3) Only the proper maintenance and inspection of-the equipment in a fixed facility can assure the delivery of dry fuel to the refueling equipment, hydrant, and/or pit system.

(4) Every possible precaution must be taken to prevent contamination of tanks and piping by water. Daily handling procedures should be designed to reveal any malfunctions of equipment or other conditions which would indicate maintenance is necessary.

(i) The major items of an operational nature should be checked and maintained on a minimum daily, weekly, monthly, and demand basis.

(ii) Complete and accurate operating logs of all phases of the fuel handling system should be developed to fit the needs of each particular operation. Entries in those logs should not only include the daily, weekly, monthly, and demand checks, but should also include all information pertaining to fuel receipt, inventory, and delivery.

(5) Refueling from drum storage or cans should be considered as an unsatisfactory operation and one to be avoided whenever possible. All containers of this type should be regarded with suspicion and the contents carefully inspected, identified, and checked for water and other contamination.

(i) If it is necessary to use this type of storage, the drums or cans should, if practicable, be protected from the sun and weather. All drums should be stored off the ground and on their sides, with the bungs below the liquid level, and in such a manner that they are visible and accessible. Additionally, fuel in the drums or cans should be used according to the fueling delivery date - -oldest stock first.

(ii) Only sound clean drums with good interiors should be used. Where fuel storage in drums has occurred for long periods, the use of the fuel is questionable unless it has been tested for quality. Bungs should always be screwed tightly into empty drums because an open bunghole allows hazardous vapors to escape from the drum after the drum has been emptied.

(iii) When fueling from drums, it is advisable to use a 5-micron filtered portable pumping unit, the best filtering equipment available locally or, as a last resort, a chamois skin filter and filter funnel.

(iv) Remember refueling from drums or cans is considered to be unsatisfactory. Extraordinary precautions are necessary to eliminate the hazards of water and other contaminants.

b. Refueling Trucks. Tank bottom drains are provided to allow the truck operator to check for the presence of water. Avgas fuelers are provided with a fuel filter capable of filtration of particles about 5 microns in size at rated flow of the fueler. The filters are equipped with a bottom drain. Turbine (jet) refuelers are provided with a filter/separator capable of removing free water. The filter is equipped with a manual bottom drain. Although the filter is not equipped with an automatic water drain, it is equipped with an automatic shutoff device to stop the flow of fuel in the event excessive amounts of water are removed from the fuel.

(1) All tank and filter bottom drains should be checked for water. Accumulations should be removed after each reloading, after washing of the equipment, after a heavy rain or snow storm, and/or daily, or more often when in accordance with the fuel distributor's instructions.

(2) Inspection and maintenance of truck filters and filters/separators are similar to those described for fixed facilities in paragraph 7(a)(2). Keeping refuelers filled with fuel will also help reduce the accumulation of water from condensation.

c. Aircraft Fuel Tanks. Aircraft fuel tanks are constructed with sumps to trap water. Since it is practically impossible to drain all water from the tanks through the fuel lines, the fuel tank sumps should be regularly drained 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 in order to completely drain all the water.

(1) On certain tailwheel type aircraft, raising the tail to level flight attitude may be necessary to get any water in a tank to flow to the gascolator or main fuel strainer so that it can be drained.

(2) In aircraft containing crossfeed systems, the crossfeed system should be utilized, and fuel should be passed or pumped through the system and subsequently drained to make sure the crossfeed lines are free of water. If water that accumulates in the crossfeed system is left un-drained, it will flow through the fuel lines to the engine(s) and may cause the engine(s) to lose power or stop operating.

(3) On 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 because fuel will take the path of least resistance. In this case, the fuel selector valve should be positioned at each respective tank in turn, and the sump should be checked for water and drained of all water after each individual tank selection.

(4) During preflight, a generous sample of gasoline (10 ounces or more) should be drained into a transparent container from each of the fuel sumps and from the main fuel strainer or gascolator. Visually check the fuel sample for water and by the clean and bright test. ' Remember bright is dry! For jet fuel, the ' white bucket or steel bucket test is appropriate to check fuel for water. Continue to drain fuel from the contaminated sump until certain the system is clear of all water. The use of quick-drain valves in the sumps and gascolators makes it easier to keep tanks free of significant quantities of water.

(5) At postflight, completely fill the fuel tanks to provide an effective method against contamination from condensation. However, this procedure may be only practical on a few types of aircraft, since the type of aircraft, length of proposed flight, number of passengers, and weight and balance limitations dictate the amount of fuel to be added.

(6) During routine maintenance, in addition to the preflight and postflight procedures, certain precautionary or routine maintenance should be performed on an aircraft including the inspection and cleaning of fuel tank outlet finger stainers, carburetor screens (filters), and flushing of the carburetor bowl.

8. REPORTED PROBLEM AREAS AND RELATED INFORMATION.

a. Aircraft Fuel Tank Caps

(1) Routine monitoring of the FAA service difficulty data bank revealed continuing failures of the vented fuel tank caps installed on aircraft.

(2) Reported failure causes include warpage, cracks, and obstructed vents. Twenty failures were reported as warped, broken, and leaking caps. Aircraft have encountered problems with fuel siphoning from around the filler caps and problems with fuel cap vents.

(3) A review of data in the FAA accident/incident data system revealed that some emergency landings were made in which the fuel storage system was listed as a causal factor. In many of those emergency landings, vented fuel. caps were* listed as a cause. The design of the vent opening allowed water to enter the fuel tanks. New types of vented fuel caps were designed for installation by the aircraft manufacturers to correct

this problem. Information about these new design vented fuel caps can be found in the Aircraft Manufacturer's Service Bulletins.

b. Fuel Tank Drains. Many airplanes are equipped with fuel reservoirs (separate tanks) in addition to the wing fuel tanks. On these airplanes, the fuel reservoirs, as well as the wing fuel tanks, should be checked for contamination when water or other contaminants are found in the fuel system. Refer to the appropriate owner's manual for fuel reservoir location and proper draining procedures. Additionally, manufacturers' service information can be referenced for installation of fuel tank quick drain-kits. These kits are now available for airplanes built between 1946 and 1974.

9. WATER CONTAMINATION. Normally, upon finding water contaminated fuel the procedures for removal of water outlined in this advisory circular should suffice. Should contamination persist or any doubt exists as to water contamination, the advice is to have the aircraft fuel system inspected by a qualified person.

10. SUMMARY. The best insurance against a water-in-fuel problem, whether aviation gasoline or jet fuel, is a responsible fuel handling chain. The information and procedures outlined in this advisory circular as well as good inspection and housekeeping practices and constant vigilance should significantly reduce the possibility of an aircraft accident due to water-in-fuel contamination.

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