AVIATION FUEL

HANDLING GUIDE

Video Tour 

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Chapter 1. Fuel Contaminants

Aviation Fuels are produced at refineries to meet the applicable ASTM specification (D910 for Aviation Gasoline and D1655 for Aviation Turbine Fuel). After being manufactured, the fuel may move through various modes of transportation (pipelines, ships, barges, rail cars, road transports) and storage tanks at the refinery and pipeline terminals. Once the fuel reaches the airport, it may move through various equipment (storage tanks, piping, mobile refueling equipment, fixed dispensing equipment) prior to being delivered into the aircraft. As the fuel moves through this distribution network, contaminants may be introduced into the fuel. Potential contaminants include free water, particulate matter, surfactants, microorganisms or cross contamination with other products. It is important to understand the different types of fuel contaminants, the sources of the contaminants and how the contaminants can be identified and eliminated. Fuel contamination may also occur in the aircraft but the subject matter addressed below only relates to fuel contamination prior to introduction into the wing of the aircraft.

1.1 Water Contamination

- Water is the most common contaminant found in aviation fuel and falls into the following two categories
  - **Dissolved Water** (Water in Solution)
    - Does not present a risk to aircraft engine operation
    - The amount of water that fuel can hold in solution is a function of the fuel temperature
    - The higher the temperature of the fuel, the greater the potential concentration of dissolved water
    - As fuel cools, it can hold less water in solution and the water condenses out of the fuel as free water
  - **Free Water** (Undissolved Water)
    - Any water that is not dissolved in the fuel
    - Accumulates at low points in fueling systems and settles to the bottom of tanks because it is heavier than fuel

1.1.1 Sources of Free Water

- Movement of "water in solution" into "free water"
- Introduced into the fuel from outside sources
  - Condensation of water vapor (humidity) in any air space inside fuel storage tanks, piping and filter vessels
  - Fuel handling equipment integrity issues (leaks in fittings, fill caps, manways, etc.)
  - Water laden transport deliveries

1.1.2 Risks of Free Water

- A water slug reaching the engine could cause performance issues
- At high altitudes (colder temperatures) free water can form ice crystals which can plug aircraft fuel system filters and fuel control units
- Water enables microbial activity in fuel storage
- The presence of water in a storage tank can cause the FSII additive in jet fuel to migrate out of the fuel and into the water, at the fuel-water interface

1.1.3 Detecting Free Water

- Field Testing
  - White Bucket Test – Free water in fuel may be observed as a hazy/cloudy appearance, water droplets, or bulk water
    see Section 5.5 Fuel Quality Testing – White Bucket Test

    Note: Free water is typically not visible to the eye until it reaches levels greater than 30 parts per million (PPM)
  - Free Water Test – ATA Specification 103 recommends a maximum allowable limit of 15 PPM downstream of filtration
    see Section 5.3 Fuel Quality Testing – Free Water Test

1.1.4 Preventing Free Water

- Maintain a thorough inspection and maintenance program
  - Tank manways should be inspected periodically to ensure integrity of seals
  - Ensure integrity of installation points of appurtenance and verify they are free from defects that would allow introduction of water
  - Perform daily tank and filter vessel sumping to detect and remove water (chronic presence of water should be investigated to identify and address the source)
- Don't accept fuel deliveries with visible water contamination
- Allow tanks to settle and then sump the tank after the receipt to detect/remove water
- Reduce potential for condensation in a storage tanks by keeping more fuel in the tank and minimizing the air space
- Install filtration at product transfer points
- Other References

GamGram 47 – ***How Does Water Get Into an Aircraft? (Part 1)***
GamGram 48 – ***How Does Water Get Into an Aircraft? (Part 2)***

1.2 Particulate Contamination

Particulate contamination is a constant threat to fuel quality at every point in the distribution system.

1.2.1 Sources of Particulate

- Rust and scale from storage tanks and piping
- Airborne solids entering through storage tank vents
- By-products of microbial infestation
- Fueling system components (damaged fueling hose and couplers, filter media, pump and meter debris, etc.)

1.2.2 Risks of Particulate

- Particulate matter present in the fuel can plug aircraft fuel filters and cause engine performance issues

1.2.3 Detecting Particulate

- Field testing
  - White Bucket Test – Particulates will settle out of the fuel and fall to the bottom of the bucket
    see Section 5.5 Fuel Quality Testing – White Bucket Test
  - Filter Membrane Test – Uses membrane pad color ratings to detect contaminants in jet fuel
    see Section 5.2 Fuel Quality Testing – Filter Membrane Test

1.2.4 Preventing Particulate Contamination

Most particulate contamination can be controlled (except the introduction of airborne solids entering through tank vents)

- Maintain a thorough inspection and maintenance program
  - Ensure **fuel nozzle screens** are present, properly sized and in good condition (protects against particulate contamination generated by compromised filtration or fueling system components located downstream of filtration)
  - Ensure **fuel nozzle covers** or protective devices are installed (prevents introduction of airborne solids)
  - Perform daily tank and filter vessel sumping to detect and remove any particulates (chronic presence of particulates should be investigated to identify and address the source)
- Don't accept fuel deliveries with visible particulate contamination
- Allow tanks to settle and then sump the tank after the receipt to detect and remove any particulates
- Use of corrosion resistant materials such as stainless steel and interior epoxy coatings on storage tanks and fueling systems
- Install filtration at product transfer points
- Other References

GamGram 4 – *Anatomy of a Jet Fuel Pipe*

1.3 Surfactant Contamination

Surfactants (surface active agents) can be introduced into aviation fuels at various points in the fuel distribution system. Soaps or detergents are examples surfactant materials. They work at the interface of two immiscible liquids such as oil and water to disperse the oil into the water. Because surfactants work at the surface of the liquids, small amounts of surfactants can impact large volumes of liquids.

1.3.1 Sources of Surfactants

- Surfactants can be found in crude oil and/or introduced into fuels during the refining process
- Intentional introduction of surfactant type additives at various points in the fuel distribution system (e.g., corrosion inhibitor additive that may be used in pipelines, static dissipating additive that may be used at terminals, detergent additive that may be used in motor fuels, etc.)
- Unintentional introduction of surfactant materials

1.3.2 Risks of Surfactants

- In jet fuel, surfactants can create a binding affect on the free water that would normally separate from fuel due to differences in density and/or surface tensions
  - Causes free water to remain suspended in the fuel for an extended period of time creating an emulsion
- Disarm coalescer elements
  - Presence of surfactants at the surface of small water droplets prevents them from coalescing into larger drops as they move through coalescing media and out of the coalescer element
  - Smaller entrained water droplets will not fall to the filter sump area for removal allowing free water to move downstream of the filter vessel

Coalescing – Surfactant Contamination (Hazing)

1.3.3 Detecting Surfactants

- Field testing
  - White Bucket Test – Surfactants may appear in tank or filter vessel sump samples as a lacy like material at the fuel/water interface, a soapy sudsy type material on the surface of the fuel or brownish colored water
    see Section 5.5 Fuel Quality Testing – White Bucket Test
    Note: Surfactant contamination may display many of the characteristics of microbial activity byproducts and may require laboratory testing to confirm the source of the observed contaminant
  - SWIFT Kit® – Field test to measure the interfacial tension of aviation turbine fuel as an indicator of surfactant contamination
- Lab testing
  - MSEP (Micro-separometer) ASTM D3948
    - Indicates the water separation characteristics of jet fuel
    - Fuel containing surfactants will have a reduced water separation characteristics

1.3.4 Preventing Surfactant Contamination

- Proper manufacturing and transportation of the fuel in addition to good fuel handling procedures
- Clay treatment is utilized at terminals supplied by multi-product pipelines to remove surfactants from jet fuel prior to delivery to airport facilities
- Don't accept fuel with visible surfactant contamination
- Don't use soaps or detergents to clean the interiors of storage tanks, filter vessels, re-useable filter elements, etc.

1.3.5 Other References

- ASTM D3948 – Standard Test Method for Determining Water Separation Characteristics of Aviation Turbine Fuel by Portable Separometer

GamGram 14 – *Clay Treatment of Jet Fuel*

GamGram 28 – *WSIM, MSEP and Swift Kit*

1.4 Microorganism Contamination

Microorganisms (microbes) may be introduced to aviation fuels at various points in the fuel distribution system and cause a variety of problems.

1.4.1 Sources of Microorganisms

- Microorganisms generally enter aviation fuel after the refining process
- Fuel system microorganisms are made up of bacteria and fungi (yeasts and molds)
- In order for microbes to grow, they need a source of nutrition and water
  - Aviation fuel hydrocarbons provide the source of nutrition
  - Microbes will remain dormant until a water source is available

1.4.2 Risks of Microorganisms

- Microbial activity can disarm coalescer elements
- Acidic nature of the microbial byproducts can cause metal corrosion and degradation of filter elements
- By-products of microbial activity can create problems in aircraft including plugging fuel filters, fouling fuel probes and corrosion damage to fueling system plumbing and fuel tanks

1.4.3 Detecting Microorganisms

- Field testing
  - White Bucket Test – Presence of microbial activity may be indicated by slimy or matted material floating or suspended in the fuel, dark colored water, pungent odor similar to rotten eggs
    see Section 5.5 Fuel Quality Testing – White Bucket Test
  - Various field test kits are available to help detect active microbes
- Laboratory testing
  - Applicable ASTM Standards

    Note: Filter elements exhibiting leopard spotting is also an indication of microbial contamination

1.4.4 Preventing Microorganism Contamination

- Since free water is needed to support microbial growth, daily sumping of storage tanks and filter vessels to detect and remove free water is recommended
- Design aviation fueling systems to facilitate the removal of all free water
- Don't accept fuel with visible microorganism contamination
- If microbial contamination is identified in a fueling system, treatment options are available but they must be conducted in compliance with various standards

1.4.5 Other References

- ASTM D6469 – Standard Guide for Microbial Contamination in Fuels and Fuel Systems
- ASTM D6974 – Standard Practice for Enumeration of Viable Bacteria and Fungi in Liquid Fuels – Filtration and Culture Procedures

1.5 Cross Contamination from Other Products

Introduction of other products into aviation fuels will result in the alteration of the performance characteristics of the fuel as specified by the applicable ASTM Standard (D910 for Aviation Gasoline and D1655 for Aviation Turbine Fuel).

1.5.1 Sources of Cross Contamination

- Contamination by a different grade or type of fuel (or other products) may occur in the fuel distribution system at any point where fuel is received or transferred

1.5.2 Risks of Cross Contamination

- Fuel co-mingled with other grades or types of fuel may not meet the applicable ASTM Standard

1.5.3 Detection Cross Contamination

- Field testing
  - White Bucket Test – Unfamiliar color of fuel or presence of dye (other than blue dye used in 100 LL aviation gasoline) may be an indication of cross contamination
    see Section 5.5 Fuel Quality Testing – White Bucket Test
  - API Gravity Test – A change in the density of the fuel may indicate cross contamination with other products
    see Section 5.1 Fuel Quality Testing – API Gravity Test
- Lab testing
  - Complete recertification to applicable ASTM Standard

1.5.4 Preventing Cross Contamination

- Use product dedicated transport trucks
- Follow proper receipt of fuel procedures
  see Section 6.4 Operational Procedures - Receipt of Fuel
- Use dedicated fueling equipment
- Use product specific connections for receiving and dispensing different grades of fuel
- Mark airport equipment marking for fuel identification
  see Section 3.2.9 Fixed Storage - Signs, Placards & Labels
  see Section 4.2.9 Refueler – Signs, Placards & Labels
- Follow misfueling prevention best practices and guidance
  - Vigilance is required when receiving fuel into storage, uplifting fuel into refuelers and uplifting fuel into aircraft

1.5.5 Other References

EI 1542 – ***Identification Markings for Aviation Fuel Distribution Facilities, Airport Storage and Mobile Fueling Equipment***

EI 1597 – ***Procedures for Overwing Fueling to Ensure Delivery of the Correct Fuel Grade to an Aircraft***

GamGram 20 – ***Recipes for Disaster***

Chapter 2. Filtration

Since fuel may become contaminated at any point in the distribution system, filtration equipment is used throughout the system to remove water, particulate and other contaminants (e.g. surfactants). Filtration becomes increasingly important as the fuel gets closer to the aircraft wing.

It is recommended that aviation fuel be filtered as it is transferred into and out of fuel farm storage and immediately upstream of into-wing dispensers (fixed and mobile).

Following is summary of the various types of filtration used with aviation fuels. It is important to understand the differences in design and functionality when selecting filtration equipment. The airlines and military may have specific guidance on filtration requirements.

2.1 Filter/Separator (Two-Stage Filtration)

- Also known as a "Coalescer/Separator" and "Filter Water Separator" (FWS)
- Removes water and particulate contaminants from fuel

Basics of Filter Separator Vessels

Filter Separator Diagram

  - 1st Stage - Filter
    - Coalesce extremely small drops of free water entrained in the fuel into large drops that fall by gravity into the vessel sump

Coalescing: Good Vs. Poor

    - Removes particulate contaminants from the fuel; the cumulative effect of particulate build-up on the element will ultimately restrict fuel flow and cause an increase in differential pressure (DP)
    - Elements are made of fiberglass and pleated paper

Coalescer Cartridge Model Number Description - Velcon

- 2nd Stage - Separator
  - Repels previously coalesced water droplets from moving downstream of the vessel
  - Elements are made of water repellent material such as Teflon, synthetic material or silicon treated paper

Separator Cartridge Model Number Description - Velcon

- As water is coalesced and drops to the sump, fuel continues to flow through the vessel; a water defense system is needed to prevent accumulated water from moving downstream of the filer vessel
  see Section 6.5 Operational Procedures - Water Defense Systems
- Single element vessels with two-stage functionality are available for lower flow rate applications

Filter Separator - Single Element Diagram

- EI 1581 qualification covers both the vessel and filter elements
- Other References

EI 1581 5th Edition Summary

EI 1581 – ***Specifications and Qualification Procedures for Aviation Jet Fuel Filter/Separators***

GamGram 8 – ***API/IP 1581 5th Edition (now EI)***
GamGram 9 – ***Further Explanations – API/IP 5th Edition (now EI)***
GamGram 30 – ***Cold Weather Operation of Filter Separators***

2.1.1 Qualification of Filter/Separator by Similarity

- EI 1582 specifies the minimum requirements for a filter/separator system to qualify to EI 1581 by similarity using a calculation methodology instead of laboratory testing
- Similarity criteria may only be used for filter/separator filtration and only on systems with a flow rate less than or equal to the design that was qualified by full-scale Allows manufacturers to qualify a range of vessel sizes without having to run full-scale testing on each one, based on the theory that, if a candidate filtration system can be shown to be sufficiently similar to a system already qualified by full-scale testing, it supports the expectation that it would indeed meet EI 1581 qualification testing requirements
- Ensures that a new or existing filter/separator remains qualified to EI 1581 when the model/type of elements installed is changed
- Manufacturers are required to provide similarity documentation (similarity sheet and a data or conversion vessel plate) for any qualified vessel
  - Similarity request form is submitted to the filter vessel manufacturer to provide information required to allow the qualification by similarity rather than laboratory testing

    Similarity Certification Request Form - Velcon

    Similarity Certification Request Form - Facet

  - Similarity Data Sheet is produced to show that the operating parameters of the candidate vessel (with elements) is sufficiently similar to a system, already qualified by laboratory testing, to support the expectation that the candidate vessel would meet EI 1581 qualification requirements

    Similarity Data Sheet Example - Velcon

    Similarity Data Sheet Example - Facet

- Certificate of Similarity document is produced to confirm qualification by similarity to EI 1581 and assigned to a specific vessel; certificate should be retained on file by the user as long as the referenced elements are installed

  Similarity Certificate Example - Velcon

  Similarity Certificate Example - Facet

- EI 1582 qualification covers only filter/separators

- Other References

  EI 1582 – ***Specification for Similarity for API/IP 1581 Aviation Jet Fuel Filter/Separators***

2.2 Filter Monitor

- Also known as a “Fuse” or “Go–No–Go” filter
- Elements are made of pleated paper (traps particulate) and a water absorbing media (Super Absorbent Polymer - SAP); similar to “baby diaper” material
- Removes particulate contaminants from the fuel; the cumulative effect of particulate build-up on the element will ultimately restrict fuel flow and cause an increase in differential pressure (DP)
- Removes water from the fuel; ultimately the flow will be stopped if the water absorbing media becomes saturated with water

Warning: Filter Monitor elements must not be used with jet fuel containing FSII additive

Basics of Filter Monitors

Filter Monitor Warning – Energy Institute

- EI 1583 qualification covers only the filter elements
- Other References

EI 1583 – ***Laboratory Tests and Minimum Performance Levels for Aviation Fuel Filter Monitors***

2.3 Microfilter

- Also known as a “Pre Filter”, “Particulate” and “Micronic”
- Elements are made of pleated paper and/or synthetic media that trap particulate
- Removes particulate contaminants from the fuel; the cumulative effect of particulate build-up on the element will ultimately restrict fuel flow and cause an increase in differential pressure (DP)
- Not designed to remove water
- Typically utilized upstream of monitor or filter/separator to reduce particulate load on downstream filtration
- EI 1590 qualification covers only the filter elements
- Other References

EI 1590 – *Specifications and Qualification Procedures for Aviation Fuel Microfilters*

2.4 Clay Treatment

- Clay treatment vessels typically utilize canisters or bags containing a special clay (attapulgus clay) with unique characteristics that significantly increase surface area
- Clay is used to treat jet fuel by removing surfactant molecules by adsorption and is not a filter media used to trap contaminants
- Contact time between the fuel and clay is critical to the performance of the clay treatment
- Treatment removes surfactants from jet fuel; surfactants may disarm coalescing elements and also makes it difficult for free water to separate from fuel
- Located upstream of filter/separators and typically found at refineries and pipeline terminals
- Other References

GamGram 14 – *Clay Treatment of Jet Fuel*

2.5 Dehydrator

- Also known as “Hay pack”
- Dehydrator vessels are typically packed with a series of wafer style repacks made of course wood fiber
- Designed to remove large particulate matter and bulk water from fuel
- Located upstream of all other filtration and typically found at marine terminals
- Used to protect clay treaters from water and particulate

2.6 Filter Vessel Appurtenances

- The following filter vessel appurtenance should be evaluated to determine application based on operational, functional, safety, and vessel qualification requirements
  - Provision for air elimination
  - Means to monitor differential pressure (DP); direct reading DP gauge with accuracy of ± 2 pounds per square inch (PSI) is recommended
  - Manual sump drains to identify and remove contaminants (valves with handles spring loaded to the closed position are recommended)
  - Upstream and downstream membrane sampling connections (including probes and dust covers) to detect the presence of particulate contaminants
  - Pressure relief valve or other device that will prevent over-pressurization due to thermal expansion of fuel (include means capturing relieved fuel)
  - Automatic water defense system for use with coalescer separator filtration that will cause fueling to stop or alert operating personnel when activated by excessive water (include provisions for an operational test)
- Other References

EI 1581 – *Specifications and Qualification Procedures for Aviation Jet Fuel Filter/Separators*

GamGram 57 – *Filter Accessories*

2.7 Filter Vessel Data

- Filtration qualified to EI 1581, 1583 or 1590 specifications should have a data plate and placards/decals attached to the vessel and include at a minimum the following information/decals

Filter Vessel Data Plate Example

	EI 1581	EI 1583	EI 1590
Manufacturer's Name and Address	✓	✓	✓
Vessel Serial Number	✓	✓	✓
Vessel Model Number	✓	✓	✓
Rated Flow Capacity	✓	✓	✓
Date of Manufacture	✓	✓	✓
Quantity and Model Number of Elements	✓	✓	✓
Recommended Maximum Differential Pressure	✓	✓	✓
Construction / Design Code	✓	✓	✓
Design Pressure	✓	✓	✓
Hydrostatic Test Pressure	✓	✓	✓
Applicable Energy Institute (EI) Specification Number	✓	✓	✓
Operational Temperature Range	✓	✓	✓
Vessel Cover Gasket Material & Part Number	✓	✓	✓
Recommended Assembly Torque	✓	✓	✓
Sump Volume	✓		
Similarity Certificate Identification	✓		
Month / Year of Last Filter Element Changeout	✓	✓	✓

- Other References

EI 1581 – ***Specifications and Qualification Procedures for Aviation Jet Fuel Filter/Separators***

EI 1583 – ***Laboratory Tests and Minimum Performance Levels for Aviation Fuel Filter Monitors***

EI 1590 – ***Specifications and Qualification Procedures for Aviation Fuel Microfilters***

2.8 Filter Element Replacement Criteria

- Filter/Separators & Filter Monitors

  see Section 6.1 Operational Procedures - Filter Element Replacement

  - Corrected differential pressure (DP) exceeds 15 PSI

    Option 1: Corrected DP
  - Sudden drop in corrected DP
  - Filter vessel sump samples indicate the presence of haze, surfactant, microbial or solid contaminants
  - Free water detection tests indicate presence of free water greater than 15 parts per million (PPM), downstream of filter vessel
  - Filter membrane test (Millipore) ratings greater than 2 dry or 3 wet, downstream of filter vessel
  - Twelve month service life has expired
  - Investigate the following
    - Sudden changes (up or down) in corrected DP
    - Short life of elements (based on previous experience)

- Microfilter
  - Observed DP exceeds 15 PSI
- Clay Treater
  - micro-separometer rating test results indicate no improvement on the downstream side of the vessel or DP exceeds 15 PSI; consult element supplier for recommended service life
- Dehydrator
  - Testing indicates free water present downstream of vessel

2.9 Differential Pressure (DP)

Observing the DP across a filter vessel is used to monitor the changing conditions of the element(s). Whenever fuel passes through a filter, there should be a drop in the pressure observed on the downstream side of the vessel. The difference between the pressure observed on the inlet side and the outlet side of the filter vessel is known as DP.

As a general rule the DP will increase as filter elements become plugged with contaminants. For example, when micro-filter or coalescer elements become plugged with particulate, the pressure drop across the vessel will increase resulting in a higher DP reading. The same will occur with filter monitor elements as they remove particulate and/or water from the fuel.

If a by-pass or rupture of filter elements occurs, the DP will drop.

Differential Pressure Tutorial coming soon !

2.9.1 Equipment

There are a variety of devices that can be used to monitor the DP across a filter vessel

- Recommended equipment is a direct read gauge that displays DP in PSI; a peak hold feature (registers the highest reading) is available on some gauges
- Two gauge systems utilize a gauge on the each side of the filter vessel to observe the upstream and downstream pressure used to calculate DP
- Single gauge utilizing a three way valve to detect the pressure on the upstream side and downstream side of the filter vessel used to calculate DP
- By nature of design and procedure, two gauge systems and three way valve operated gauges are inherently less accurate means of monitoring DP
- Condition gauges are available, but these devices do not display the actual DP
    - Direct read gauge with a pre-set zoned (green/red) display does not indicate the actual reading which prevents the collection of comparative data and limits the ability to identify a sudden decrease in DP.
    - Changeout indicators that are pre-set to a specified DP only monitor the high end DP and do not allow for monitoring actual or detecting a sudden decreases

Differential Pressure Monitoring Equipment

2.9.2 Procedure

- Observe and record DP daily
  - A random observation of DP that is within normal operating ranges has minimal value by itself, it must be compared to previous readings to have significance
  - Observed DP varies proportionately with flow rate so it must be corrected to make valid comparisons
  - DP will remain relatively constant until filter elements become plugged and will then rise at a fast rate
- Fuel must be flowing through a filter vessel for DP to be observed
  - Observe DP at a steady flow rate that is near the maximum operating flow of the pumping system and recorded at a similar flow rate each time
- DP should be checked immediately after filter elements are changed to ensure proper installation and operation of the elements

  Note: There should be an indication of positive DP at the rated flow of vessel
- **Option 1: Corrected DP** Record both observed DP and the corresponding flow rate (corrected DP can be calculated using this data)
  - Corrected DP is used to adjust the observed DP to a value that would be observed if the fueling system was being operated at 100 percent of the rated flow of the filter vessel
  - Basic concept of corrected DP:
    - Corrected DP will be higher than the observed DP if the fueling system is operating at less than 100 percent of the rated flow of the filter vessel
  - Corrected DP is used to compare to the recommended changeout DP which is typically 15 PSI

- **Option 2: Changeout DP** The recommended changeout DP, typically 15 PSI, is based on a fueling system operating at 100 percent of the rated flow of the filter vessel
  - If operating at less than 100 percent of the rated flow of the filter vessel, the changeout DP must be adjusted using the "Cartridge Changeout Curve" provided by the filter manufacturer

    Note: See "Exception" statement on the changeout curve related to "system flow limit"

    Cartridge Changeout Curve

  - Basic concept of the changeout curve:
    - If the system is operating at less than 100 percent of the rated flow of the vessel, the actual changeout DP will be lower than the recommended changeout DP

2.10 Other References

- ASTM Manual 5 – Aviation Fuel Quality Control Procedures

EI 1550 – ***Handbook on Equipment Used for the Maintenance and Delivery of Clean Aviation Fuel***

GamGram 7 – Sparks From Jet Fuel
GamGram 16 – "Micron" Ratings

Chapter 3. Fuel Storage Facility

3.1 Planning & Design Considerations

Fuel storage facility planning and design should address both current needs and future growth. In addition, there are numerous guidelines and regulations applicable to a fuel storage facility so thorough planning and evaluation is required. Because of the numerous design options and regulatory requirements, selecting a vendor with experience in aviation fuel storage facility design and construction is strongly recommended.

Planning & Design Reference Guide

3.1.1 Property

- Availability (e.g. purchase, lease)
- Size adequate for existing and/or future needs
- Fit for purpose (e.g. customer access, proximity to roads, buildings or other structures)
- Utilities (e.g. required electrical phase capacity, phone line for credit card terminal)

3.1.2 Guidelines and Regulations

- Identify applicable “authorities having jurisdiction” or “code enforcement” entities and consider various industry guidance
  - Local, City, State, Fire Marshal, etc.
  - Fuel Supplier
    (refer to Phillips 66 QA Inspection Requirements at www.TrustedFuel.com)

    Phillips 66 QA Inspection Requirements

  - National Fire Protection Association NFPA (e.g. NFPA 10, NFPA 30, NFPA 407)
  - Environmental Protection Agency EPA (e.g. SPCC and SWPP plans)
  - Department of Homeland Security DHS
  - Federal Aviation Administration FAA
  - Occupational Safety & Health Administration OSHA
  - American Petroleum Institute API

- Energy Institute (EI)
  see also Section 3.4 Fuel Storage Facility – Other References

  EI 1540 – *Design, Construction, Operation and Maintenance of Aviation Fuelling Facilities*

- Defense Logistics Agency DLA (e.g. MIL-STD-1548)
- Airlines For America A4A (e.g. ATA Specification 103)

3.1.3 General Design Considerations

- Product type(s)
- Future expansion (e.g. fuel storage facility, runway, hangars, FBO buildings)
- Safety and security provisions (e.g. perimeter fencing, bollards)
- Fire safety provisions (e.g. emergency fuel shutoff, bonding and grounding, fire extinguishers)
- Fuel Transfer Points
  - Transport offloading
  - Refueler loading
  - Fueling cabinet or dispenser
  - Self serve fueling dispenser: availability, location and credit card system
- Storage Tanks
  - Restrictions and requirements related to aboveground storage (AST) and underground storage (UST) tanks
  - Optimum number and size to manage peak demand, settling time, freight costs, fuel shelf life, etc.
  - Construction design to meet local fire codes (e.g. UL 142 Single Wall, UL 142 Double Wall, SWRI 97-04 Flameshield, UL 2085 Fireguard)
- Filtration Requiremts
  - Product compliant filtration
  - Filter vessel location and capacity (GPM); type of filter element(s)
  - Appurtenances (e.g. air eliminator, pressure relief valve, water defense, differential pressure gauge)
  - Static relaxation vessel, if necessary, with proper appurtenances (e.g. air elimination, pressure relief, sump drain)

- Spill containment (e.g. double wall tank, containment areas)
- Pump equipment and pump rate (GPM) for offloading transports, loading refuelers and fueling aircraft
- Re-circulating capability of fueling system, including cabinet or dispenser
- Anti-siphon valves (i.e. check valve)
- Compatible construction materials for aviation fuel service (e.g. refer to ATA Specification 103)
- FSII Additive Plan (jet fuel only)
  - Pre-treated at the terminal, on-site injection system (fuel farm or refuelers)
  - Additive storage (e.g. pails, drums, totes) location and safe handling

Fuel recovery system

Tech Topic – Recoverable Fuel

Fuel Recovery System Drawing

3.2 Equipment

The following section contains operational provisions and components for consideration when building a fuel storage facility; it is not intended to be all inclusive and additional considerations may be dictated by local circumstances.

3.2.1 Tanks

- Carbon steel with internal light color epoxy coating or stainless steel
- Sloped to a positive sump through construction or installation design
- Tank sumping system
  - Sump drain or permanent sump pump at low point of tank
  - Drain line made of non-rusting material such as stainless
  - Placard to indicate volume of tank drain piping (line-fill)
  - Eliminate potential waste fuel by minimizing quantity of line fill
- Secondary spill containment as required
- Cathodic protection for metal underground tanks and piping
- Compliance with local fire codes as required (e.g. UL 142 Single Wall, UL 142 Double Wall, SWRI 97-04 Flameshield, UL 2085, etc.)
- Ladders, platforms or catwalks as desired or required
- Type of suction: fixed piping or floating suction (allows fuel to be drawn from the top of the fuel inventory; should be designed with provision for operational test)
- Inlet pipe that discharges fuel near the bottom of the storage tank and designed to minimize turbulence
- Gauge hatch with slotted tube to provide means for sampling and “sticking” the tank, to check inventory level and to check for water
- Access manway(s) to allow tank entry for inspection and cleaning (compliant with OSHA confined space guidance)
- System to prevent tank overfills (alarms, positive shut downs, etc.) with provision for operational test
- Properly sized operating vents (aka working vents) with screens and designed to prevent rain water and debris from entering tank
- Properly sized emergency vents (allows for venting in case fire)
- Tank inventory gauge that displays inventory level

3.2.2 Filtration

- Recommend that fuel be filtered into and out of storage to remove particulate and water contaminants
- Important: Filtration associated with into-wing fueling should be located immediately upstream of dispensing system (includes remote dispensers/cabinets)
- Detailed filtration options are covered in see Chapter 2

3.2.3 Pressure Controls (Aircraft Single Point Fueling)

- Separate and independent primary and secondary pressure control devices
- Primary control - protects the aircraft under conditions of constant flow and from pressure surge caused during aircraft valve closure
- Secondary control – protects the aircraft if primary control fails
- Pressure control settings (per ATA Specification 103)
  - Primary pressure control devices must limit fueling pressure at the nozzle to 40 pounds per square inch (PSI) or less under constant flow conditions
  - Secondary pressure control devices must limit fueling pressure at the nozzle to 50 PSI or less under constant flow conditions

3.2.4 Deadman Control System

- Handheld control device
- Completely stops the flow of fuel within a maximum of 5 percent overrun

3.2.5 Physically Segregated Systems

- Physically segregated systems (tanks, piping, filtration, etc.) dedicated to a single type/grade product; in multi compartment tanks (not recommended) all compartments must contain the same type/grade product

3.2.6 Grade Selective Couplings

- Grade selective couplings at the transport off-load point will help prevent the wrong grade of fuel from being delivered into storage
- Grade selective couplings for the transfer of fuel into refuelers will help prevent the incorrect grade of fuel from being loaded into fueling vehicles

3.2.7 Emergency Fuel Shutoff System

- Shutoff valves or switches must be clearly identified and method of operation (e.g. "push" or "pull") indicated per NFPA 407

3.2.8 Fire Extinguishers

- Type/rating, quantity and location of fire extinguishers should be compliant with NFPA 407; general guidance as follows
- Readily accessible
- Minimum of one 20 lb., B:C rated extinguisher
- If the open hose discharge capacity of the fueling system is greater than 200 gpm, at least one wheeled extinguisher with a minimum rating of 80 B:C and minimum capacity of 125 lbs. of agent

3.2.9 Signs, Placards & Labels

General industry guidance advises that all fueling equipment be clearly marked with the proper grade of fuel being dispensed, fire safety signage (flammable, no smoking, emergency fuel shutoff) and other informational/instructional signage and labels required by any local authority having jurisdiction. Fuel storage facilities (piping, filtration, tanks, dispensers, etc.) should be identified and color coded per guidance found in the following

NFPA 407

EI 1542 – *Identification Markings for Dedicated Aviation Fuel Manufacturing and Distribution Facilities, Airport Storage and Mobile Fuelling Equipment (see Table 1)*

EI 1597 – *Procedures for Overwing Fuelling to Ensure Delivery of the Correct Fuel Grade to an Aircraft*

General minimum guidance is outlined below and may be subject to modification by local circumstances.

- Product identification prominently displayed
  - **Aviation Gasoline** – White letters (3" minimum) on red background with blue band

  - **Jet Fuel** – White letters (3" minimum) on black background with black band(s)

  - Fueling cabinets should display grade labels on all sides, top and the inside of the main access door
- **FLAMMABLE** – White letters (3" minimum) on red background prominently displayed

- **NO SMOKING** - Prominently displayed
- **EMERGENCY FUEL SHUTOFF** - Letters (2" minimum) of color that contrasts with the placard background posted adjacent to each emergency fuel shutoff control (indicate method of operation e.g., push, pull, etc.)
- Fixed equipment components (piping, valves, etc.) marked to identify grade of fuel

  Aviation Gasoline – BLUE

  Jet Fuel – BLACK
- Identification of tank drains and filter sump drains
- Identification of fueling pressure and differential pressure (DP) gauges
- Identification of location of fire extinguishers stored in enclosed compartments
- Pumping system operating procedures posted adjacent to pump controls
- Filter element change dates - month & year filter elements were last changed; posted on or near filter vessel

3.2.10 Fueling Hoses

Aviation fueling hose is classified by Grade and Type using the following characteristics: internal diameter, working pressure, operating temperature range and conductivity

- Grade 1
  - Maximum internal diameter of 1.5 inches
  - Maximum working pressure of 150
- Grade 2
  - Internal diameter of > 1.5 inches
  - Maximum working pressure of 300
- Type C
  - Non-electrically bonded hose incorporating a semi-conductive cover
  - Operating temperature range of -22 °F to 131 °F
- Type CT (fueling hose for cold temperature applications)
  - Non-electrically bonded hose incorporating a semi-conductive cover
  - Operating temperature range of -40 °F to 131 °F

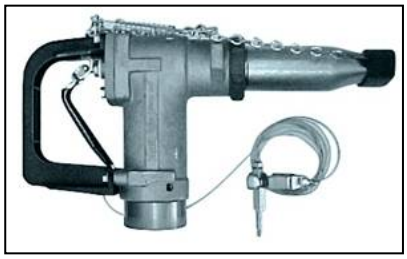
- Hoses and couplings meet EI 1529 (Grade 2 - Type C) latest edition

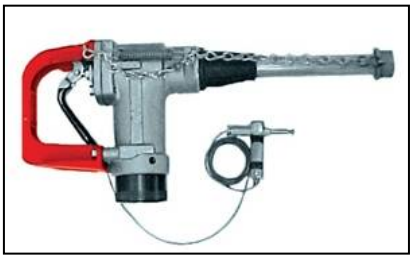
EI 1529 – ***Aviation Fueling Hose and Hose Assemblies***

- Maximum shelf life of two years from the date of manufacture
- Maximum service life of ten years from the date of manufacture

3.2.11 Fuel Nozzles

- Grade selective overwing nozzle spouts; jet fuel nozzles use a wide diameter J-Spout/Duck Bill spout (left) and aviation gasoline nozzles use a smaller diameter round spout





- Wide diameter J-spout (duckbill) for jet fuel was designed specifically as a misfueling prevention device to prevent the introduction of the wide nozzle spout into an aviation gasoline fueling port
- Color coded overwing nozzle handles and dust covers

  Jet Fuel – Black Aviation Gasoline – Red

- Equipped with 100 mesh (or finer) **nozzle screens** into aircraft
- Equipped with 60 mesh (or finer) **nozzle screens** into refueler
- **Dust covers** or other protective devices should be used to prevent debris from accumulating in/on nozzles

3.2.12 Aircraft Fueling Pressure Gauge (Aircraft Single Point Fueling)

- Use for monitoring aircraft fueling pressures (accuracy of +/- 2 percent of full scale)
- Located so it is visible during aircraft fueling operations

3.2.13 Fuel Quantity Meter

- Capable of maintaining accuracy of 0.1 percent and repeatability of 0.05 percent
- Calibrator/adjustor must be sealed

3.2.14 Electrostatic Bonding System

- Designed to equalize electrical potential between the fuel storage facility and refueler or aircraft during fueling operations

3.2.15 Other References

- ATA Specification 103 – Standard for Jet Fuel Quality Control at Airports

EI 1529 – ***Aviation Fueling Hose and Hose Assemblies***

EI 1542 – ***Identification Markings for Aviation Fuel Distribution Facilities, Airport Storage and Mobile Fueling Equipment***

- NFPA 10 – Standard for Portable Fire Extinguishers
- NFPA 407 – Standard for Aircraft Fuel Servicing
- see Section 3.4 Fuel Storage Facility – Other References

3.3 Inspections

Warning: Use Personal Protective Equipment (PPE) including eye protection, gloves and appropriate clothing to prevent contact with fuel

Routine fuel storage facility (including dispensers/cabinets) inspections and field testing is standard industry practice for aviation fuel dealers. Operations personnel should receive annual training on all aspects of these procedures. Completing regularly scheduled inspections of fueling equipment is the most effective approach for maintaining quality and safety standards at the FBO.

- Modifications to scope, content and frequency of storage facility and equipment inspections may be required based on local conditions, authorities having jurisdiction and/or customer requirements (e.g. airlines, military, etc.)
- Records should be maintained to document the results of inspections and details of maintenance work performed
  see Section 6.6 Operational Procedures – Record Keeping

Fueling Equipment Inspection Forms

The procedures outlined below summarize inspections that are commonly performed at storage facilities and are focuses on items pertaining to fuel quality and safety. Additional programs should be established to ensure environmental safety and mechanical reliability of equipment

3.3.1 Daily

3.3.1.1 Condition of Facilities and Equipment

- General condition and appearance
- Fluid leaks
- Fire safety and operating safety concerns
- Security issues

3.3.1.2 Tank Sumps

- Perform white bucket test to detect and remove visible water and contaminants see Section 5.5 Fuel Quality Testing - White Bucket Test

3.3.1.3 Filter Vessel Sumps

- Perform white bucket test to detect and remove visible water and contaminants see Section 5.5 Fuel Quality Testing - White Bucket Test

3.3.1.4 Filter Differential Pressure (DP) Observed

- Monitor/evaluate DP results on all working filter vessels

Important: see Section 2.9 Filtration - Differential Pressure

3.3.1.5 Deadman Control System

- Verify functionality of the system

3.3.1.6 Fueling Hoses, Swivels and Nozzles

- EI 1529 compliant fueling hose

EI 1529 – *Aviation Fueling Hose and Hose Assemblies*

- Check general condition for damage or excessive wear
- Check hoses for cuts, abrasions, soft spots, separation, twists or bends
- Check couplings and swivels for tightness, leaks
- Check nose and poppet seals on nozzles for cuts, nicks and wear

3.3.1.7 Dust Covers

- Ensure dust covers or other protective devices are installed and in good repair

3.3.1.8 Bonding Cables

- Check general condition of reels, cables and clamps

3.3.1.9 Fire Extinguishers

- Correct type/rating and accessible
- Tagged to indicate monthly inspection is current
- Safety seals intact
- No obvious physical damage
- Pressure gauge, if present, indicates unit is within operable range

3.3.2 Monthly

3.3.2.1 Filtration

- Perform filter membrane (Millipore) test on each coalescer/separator and monitor filter vessel in jet fuel service

  see Section 5.2 Fuel Quality Testing - Filter Membrane Test

- Perform a free water test downstream of each coalescer/separator and monitor vessel in jet fuel service

  see Section 5.3 Fuel Quality Testing - Free Water Test

3.3.2.2 Bonding System Continuity

- Perform electrical continuity check on bonding cables and clamps; maximum resistance of 10 ohms

EI 1540 – ***Design, Construction, Operation and Maintenance of Aviation Fuelling Facilities***

3.3.2.3 Fuel Hoses

- Inspect full length of hose for cuts, abrasions, soft spots, separation, twists or bends
- Check integrity of couplings at both ends of hose

3.3.2.4 Fuel Nozzle Screens

- Remove and examine for integrity and presence of debris (clean/replace as needed)

Fuel Nozzles and Screens

- If debris is discovered, investigate the cause and take appropriate corrective action

  see Section 6.3 Operational Procedures – Nozzle Screen Inspection

3.3.2.5 Signs, Placards & Labels

- Verify presence, condition and legibility of required signage

  see Section 3.2.9 Fuel Storage Facility - Signs, Placards & Labels

3.3.2.6 Floating Suction

- Verify that floating suction mechanism moves freely and floats on the fuel

3.3.2.7 Fire Extinguishers

- Maintain per NFPA 10 guidelines including the following
  - Inspect overall condition of the extinguisher (repair/recharge if needed)
    - Shell condition (rust, dents, bulges)
    - Hose condition (cracking, blockages)
    - Weight (a noticeable reduction in weight may indicate discharge)
  - Pressure gauge in green zone
  - Pin & seal in place
  - Labels are legible
  - Unobstructed access

3.3.2.8 FSII Additive

- For jet fuel containing FSII additive, verify concentration meets ASTM D1655 specification (0.10 to 0.15 volume %)
  see Section 5.4 Fuel Quality Testing - FSII Test
- For fuel storage facilities equipped with FSII injection equipment, ensure equipment is calibrated and maintained according to manufacturer's guidance

3.3.3 Quarterly

3.3.3.1 Pressure Controls (Aircraft Single Point Fueling)

- Written test protocol should be available for each vehicle and the specific design of pressure control system
- Verify proper operation of primary and secondary control equipment, adjust as necessary and record settings
- Primary pressure control system must be defeated in order to properly test the secondary control setting

3.3.3.2 Emergency Fuel Shutoff System

- Verify proper operation of each shutoff device (must completely stop the flow of fuel within a maximum of 5 percent overrun)

3.3.3.3 Deadman Control System

- Verify proper operation of each shutoff device (must completely stop the flow of fuel within a maximum of 5 percent overrun)

3.3.3.4 Water Defense System

- Externally check for satisfactory operation

  see Section 6.5.3 Operational Procedures - Quarterly External Check

3.3.3.5 Overfill Protection

- Verify satisfactory operation of sensing devices and controls

3.3.4 Semi-Annual

3.3.4.1 Hose Pressure Checks

- For hoses operated under pressure and fitted with reusable couplings, pressure test per

  EI 1540 – *Design, Construction, Operation and Maintenance of Aviation Fuelling Facilities*

3.3.5 Annual

3.3.5.1 Storage Tank

Warning: Do not enter tank without confined space permit; fuel vapors can be deadly. Ensure proper fall protection for fall arrest.

- Visually inspect for cleanliness and condition of coating
- Clean as needed

3.3.5.2 Filter Differential Pressure (DP) Gauges

- Verify proper operation in accordance with gauge manufacturer's procedures (accuracy must be within +/- 2 PSI); e.g. the Gammon DP gauge instruction manual includes operational check and calibration certificate procedures
- If present, check the DP gauge protection filter element (prevents dirt from entering through the high pressure connection) and replace as necessary

3.3.5.3 Nozzle Fueling Pressure Gauge (Aircraft Single Point Fueling)

- Verify accuracy is within +/- 2 percent of full scale

3.3.5.4 Filter Element Replacement

- see Section 2.8 Filter Element Replacement Criteria
- see Section 6.1 Filter Element Replacement

3.3.5.5 Filter Sump Heaters

- If present, check operation per manufacturer's specifications

3.3.5.6 Operating Tank Vents

- Inspect general condition of vents, replace damaged screens and remove any debris

3.3.5.7 Cathodic Protection Systems

- If present, confirm satisfactory operation

3.3.5.8 Line Strainer

- Remove and examine for integrity and presence of debris (clean/replace as needed)
- If debris is discovered, investigate the cause and take appropriate corrective action

3.3.5.9 Water Defense System

- Verify operation per manufacturer's recommendations

see Section 6.5.4 Water Defense Systems - Annual Inspection & Test

3.3.5.10 Meter Calibration (Into Aircraft Only)

- Check accuracy of meters
- Adjust meters to an accuracy of 0.1 percent and verify repeatability of 0.05 percent

  Note: Adhere to calibration accuracy and repeatability tolerances per NIST Handbook 44 where required by state or local regulation

- After calibration is complete, seal meter adjusters/calibrators

3.4 Other References

- ASTM Manual 5 – Aviation Fuel Quality Control Procedures
- ATA Specification 103 – Standard for Jet Fuel Quality Control at Airports

EI 1529 – ***Aviation Fueling Hose and Hose Assemblies***

EI 1540 – ***Design, Construction, Operation and Maintenance of Aviation Fuelling Facilities***

EI 1541 – ***Performance Requirements for Protective Coating Systems Used in Aviation Fuel Storage Tanks and Piping***

EI 1542 – ***Identification Markings for Aviation Fuel Distribution Facilities, Airport Storage and Mobile Fueling Equipment***

EI 1581 – ***Specifications and Qualification Procedures for Aviation Jet Fuel Filter/Separators***

EI 1583 – ***Laboratory Tests and Minimum Performance Levels for Aviation Fuel Filter Monitors***

EI 1590 – ***Specifications and Qualification Procedures for Aviation Microfilters***

EI 1596 – ***Design and Construction of Aviation Fuel Filter Vessels***

EI 1597 – ***Procedures for Overwing Fuelling to Ensure Delivery of the Correct Fuel Grade to an Aircraft***

- NFPA 10 – Standard for Portable Fire Extinguishers
- NFPA 30 – Flammable and Combustible Liquids Code
- NFPA 407 – Standard for Aircraft Fuel Servicing
- MIL-STD-1548 - Intoplane Servicing at Commercial Airports

Chapter 4. Refueler

4.1 Design

Refueler design specifications cover several main areas including the chassis, tank and fueling system. These components must be integrated and aligned to meet the intended operating application. There are numerous guidelines and regulations applicable to refueler equipment (API, ASME, A4A, DLA, DOT, EI, NFPA, OSHA, etc.). Many options for the fuel dispensing system must be evaluated (basic operating system design, selection of components and placement on the chassis, required flow rates, etc.). Because of the numerous design options and regulatory requirements, selecting a vendor with experience in building refuelers is strongly recommended.

4.2 Equipment

The following section contains components for consideration when developing specifications for refueler equipment; it is not intended to be all inclusive and additional considerations may be dictated by local circumstances

Note: Content in this section also applies to other equipment systems designed to fuel aircraft directly (e.g., fueling cabinets and dispensers)

4.2.1 Tanks

- Stainless steel, aluminum or epoxy coated carbon steel
- Water drain for each tank compartment (valves spring loaded to the closed position are recommended)
- Dome covers with:
  - Forward mounted hinges and latches
  - Water-tight fuel resistant seals and gaskets
- High level shutoff for refuelers equipped with bottom loading
- Designed to recirculate fuel back through the tank

4.2.2 Filtration

- Detailed filtration options are covered in see Chapter 2

4.2.3 Pressure Controls

- Separate and independent primary and secondary pressure control devices
- Primary control - protects the aircraft under conditions of constant flow and from pressure surge caused during aircraft valve closure
- Secondary control – protects the aircraft if primary control fails
- Typical commercial pressure control settings per ATA Specification 103
  - Primary pressure control devices must limit fueling pressure at the nozzle to 40 pounds per square inch (PSI) or less under constant flow conditions
  - Secondary pressure control devices must limit fueling pressure at the nozzle to 50 PSI or less under constant flow conditions

4.2.4 Deadman Control System

- Handheld control device
- Completely stops the flow of fuel within a maximum of 5 percent overrun

4.2.5 Physically Segregated Systems

- Physically segregated systems (tanks, piping, filtration, etc.) dedicated to a single type/grade product; in multi compartment tanks all compartments must contain the same type/grade product

4.2.6 Grade Selective Couplings

- Grade selective couplings for the transfer of fuel into refuelers will help prevent the incorrect grade of fuel from being loaded into fueling vehicles

4.2.7 Emergency Fuel Shutoff System

- Shutoff controls must be clearly identified and method of operation (e.g. “push” or “pull”) indicated per NFPA 407
- Accessible from each side of the vehicle
- Designed to close the tank outlet valve(s) and completely stop the flow of fuel within a maximum of 5 percent overrun

4.2.8 Fire Extinguishers

- Type/rating, quantity and location of fire extinguishers should be compliant with NFPA 407; general guidance as follows
  - Readily accessible and mounted on opposite sides of the refueler
  - Minimum of one 20 lb., B:C rated extinguisher

4.2.9 Signs, Placards & Labels

General industry guidance advises that all fueling equipment be clearly marked with the proper grade of fuel being dispensed, fire safety signage (flammable, no smoking, emergency fuel shutoff) and other informational/instructional signage and labels required by any local authority having jurisdiction. Fuel storage facilities (piping, filtration, tanks, etc.) should be identified and color coded per guidance found in

EI 1542 – ***Identification Markings for Dedicated Aviation Fuel Manufacturing and Distribution Facilities, Airport Storage and Mobil Fueling Equipment***

EI 1597 – ***Procedures for Overwing Fuelling to Ensure Delivery of the Correct Fuel Grade to an Aircraft***

- NFPA 407 – Standard for Aircraft Fuel Servicing

General minimum guidance is outlined below and may be subject to modification by local circumstances.

- Product identification posted on each side and rear of refueler
  - **Aviation Gasoline** – White letters (3" minimum) on red background with blue

  - **Jet Fuel** – White letters (3" minimum) on black background with black

  - EI 1597 recommends additional posting of the product identification on the front and in the cab of the refueler and that product identification decals be visible from each fueling hose reel and bottom load adapter
- **FLAMMABLE** - White letters (3" minimum) on red background posted on each side and rear of refueler

- **NO SMOKING** - Posted on at least two sides and prominently in cab of refueler

- **Department of Transportation (DOT) Hazard Classification Placards**

AVGAS

JET FUEL

- **EMERGENCY FUEL SHUTOFF** - Letters (2" minimum) of a color that contrasts with the placard background posted adjacent to each emergency fuel shutoff control (indicate method of operation e.g., push, pull, etc.)
- Identification of tank drains and filter sump drains
- Identification of fueling pressure and differential pressure (DP) gauges
- Identification of location of fire extinguishers stored in enclosed compartments
- Pumping system operating procedures posted adjacent to pump controls
- Filter element change dates - month & year filter elements were last changed; posted on or near filter vessel

4.2.10 Brake Interlock System

- Prevents the movement of the vehicle when
  - Couplers and/or fuel nozzles are not stowed
  - Pumping system is activated
  - Bottom loading coupler is connected
- Equipped with an override device

4.2.11 Aircraft Fueling Hose

Aviation fueling hose is classified by Grade and Type using the following characteristics: internal diameter, working pressure, operating temperature range and conductivity

- Grade 1
  - Maximum internal diameter of 1.5 inches
  - Maximum working pressure of 150 PSI
- Grade 2
  - Internal diameter of > 1.5 inches
  - Maximum working pressure of 300 PSI
- Type C
  - Non-electrically bonded hose incorporating a semi-conductive cover
  - Operating temperature range of -22 °F to 131 °F
- Type CT (fueling hose for cold temperature applications)
  - Non-electrically bonded hose incorporating a semi-conductive cover
  - Operating temperature range of -40 °F to 131 °F
- Hoses and couplings meet EI 1529 (Grade 2 - Type C) latest edition

EI 1529 – *Aviation Fueling Hose and Hose Assemblies*

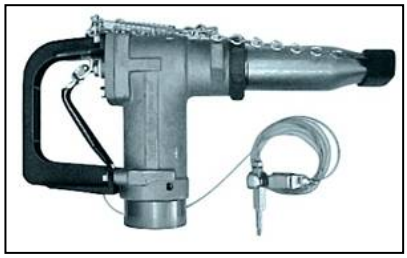
- Maximum shelf life of two years from the date of manufacture
- Maximum service life of ten years from the date of manufacture

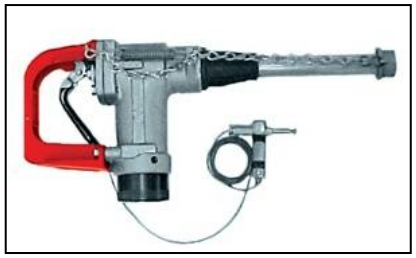
4.2.12 Manual Isolation Valves

- Installed upstream of each delivery hose if equipped with multiple aircraft delivery hoses

4.2.13 Fuel Nozzles

- Grade selective overwing nozzle spouts; jet fuel nozzles use a wide diameter J-Spout/Duck Bill spout (left) and aviation gasoline nozzles use a smaller diameter round spout





- Wide diameter J-spout (duckbill) for jet fuel was designed specifically as a misfueling prevention device to prevent the introduction of the wide nozzle spout into an aviation gasoline fueling port
- Color coded overwing nozzle handles and dust covers

  Jet Fuel – Black Aviation Gasoline – Red

- Equipped with 100 mesh (or finer) **nozzle screens** into aircraft
- **Dust covers** or other protective devices should be used to prevent debris from accumulating in/on the nozzle

4.2.14 Fueling Pressure Gauge

- Use for monitoring aircraft fueling pressures (accuracy of +/- 2 percent of full scale)
- Located so it is visible during aircraft fueling operations

4.2.15 Fuel Quantity Meter

- Capable of maintaining accuracy of 0.1 percent and repeatability of 0.05 percent
- Calibrator/adjustor must be sealed

4.2.16 Electrostatic Bonding System

- Designed to equalize electrical potential between the refueler and aircraft during fueling operations

4.3 Inspections

Warning: Use Personal Protective Equipment (PPE) including eye protection, gloves and appropriate clothing to prevent contact with fuel

Routine refueler equipment inspections and testing are standard industry practices for aviation fuel dealers. Operations personnel should receive annual training on all aspects of these procedures. Completing regularly scheduled inspections of fueling equipment is the most efficient approach for maintaining quality and safety standards at the FBO.

- Modifications to scope, content and frequency of facility and equipment inspections may be required based on local conditions and any applicable authority having jurisdiction
- Records should be maintained to document the results of inspections and details of maintenance work performed

Fueling Equipment Inspection Forms

The procedures outlined below summarize the inspections that are commonly performed on refuelers and are directed to items pertaining to fuel quality and safety. Additional programs should be established to ensure environmental safety and mechanical reliability of equipment.

4.3.1 Daily

4.3.1.1 Condition of Vehicle

- General condition and appearance
- Engine and chassis
- Fuel leaks
- Safety issues

4.3.1.2 Tank Sumps

- Perform white bucket test to detect and remove visible water and contaminants

see Section 5.5 Fuel Quality Testing - White Bucket Test

4.3.1.3 Filter Vessel Sumps

- Perform white bucket test to detect and remove visible water and contaminants

see Section 5.5 Fuel Quality Testing - White Bucket Test

4.3.1.4 Filter Differential Pressure (DP) Observed

- Monitor/evaluate DP results on all working filter vessels

Important: see Section 2.9 Filtration - Differential Pressure

4.3.1.5 Deadman Control System

- Verify functionality of the system

4.3.1.6 Brake interlock System

- Verify proper operation

4.3.1.7 Nozzle Fueling Pressure

- Monitor periodically during fueling operations and record
- Should not exceed 40 PSI under constant flow conditions
- Pressure fluctuations exceeding +/- 10 PSI under constant flow should be investigated

4.3.1.8 Fueling Hoses, Swivels and Nozzles

- Check general condition for damage or excessive wear
- EI 1529 (Grade 2 - Type C) latest edition, fueling hose

EI 1529 – *Aviation Fueling Hose and Hose Assemblies*

- Check hoses for cuts, abrasions, soft spots, separation, twists or bends
- Check couplings and swivels for tightness, leaks
- Check nose and poppet seals on nozzles for cuts, nicks and wear

4.3.1.9 Dust Covers

- Ensure dust covers or other protective devices are installed and in good repair

4.3.1.10 Bonding Cables

- Check general condition of reels, cables and clamps

4.3.1.11 Fire Extinguishers

- Correct type/rating and accessible
- Tagged to indicate monthly inspection is current
- Safety seals intact
- No obvious physical damage
- Pressure gauge, if present, indicates unit is within operable range

4.3.1.12 Tank Trough

- Verify free from standing water (clear drains if standing water present)

4.3.1.13 Bottom Load Precheck

- Verify operation of high level shutoff (precheck) systems

4.3.2 Monthly

4.3.2.1 Filtration

- Perform filter membrane (Millipore) test on each coalescer/separator and monitor filter vessel in jet fuel service
  see Section 5.2 Fuel Quality Testing - Filter Membrane Test
- Perform a free water test downstream of each coalescer/separator and monitor vessel in jet fuel service
  see Section 5.3 Fuel Quality Testing - Free Water Test

4.3.2.2 Bonding System Continuity

- Perform electrical continuity check on bonding cables and clamps; maximum resistance of 10 ohms per EI 1540

4.3.2.3 Fueling Hose

- Inspect full length of hose for cuts, abrasions, soft spots, separation, twists or bends
- Check integrity of couplings at both ends of hose

4.3.2.4 Fuel Nozzle Screens

- Remove and examine for integrity and presence of debris (clean/replace as needed)

Fuel Nozzles and Screens

- If debris is discovered, investigate the cause and take appropriate corrective action
  see Section 6.3 Operational Procedures – Fuel Nozzle Screen Inspection

4.3.2.5 Signs, Placards & Labels

- Verify presence, condition and legibility of required signage
  see Section 4.2.9 Refueler – Signs Placards & Labels

4.3.2.6 Meters

- Verify meter calibrators are sealed

4.3.2.7 Fire Extinguishers

- Maintain per NFPA 10 guidelines including the following
  - Inspect overall condition of the extinguisher (repair/recharge if needed)
    - Shell condition (rust, dents, bulges)
    - Hose condition (cracking, blockages)
    - Weight (a noticeable reduction in weight may indicate discharge)
  - Pressure gauge in green zone
  - Pin & seal in place
  - Labels are legible
  - Unobstructed access
  - Update inspection tag after inspection completed

4.3.2.8 Emergency Fuel Shutoff

- Verify proper operation of each shutoff device (must completely stop the flow of fuel within a maximum of 5 percent overrun)

4.3.2.9 Deadman Control System

- Verify proper operation of each shutoff device (must completely stop the flow of fuel within a maximum of 5 percent overrun)

4.3.2.10 Tank Interior

Warning: Fuel vapors can be deadly; ensure proper fall protection

- Visually inspect from the dome cover opening for presence of fuel contaminants

4.3.2.11 Dome covers

- Check condition of cover, latches, hinges, seals and gaskets

4.3.2.12 Tank Vents

- Verify proper operation

4.3.2.13 Trough Drains

- Verify free from any obstructions

4.3.2.14 FSII Additive

- If fuel storage facility is equipped with FSII additive injection equipment, verify that the FSII additive concentration meets ASTM D1655 specification
  (0.10 to 0.15 volume %)
  see Section 5.4 Fuel Quality Testing - FSII Test
- For refuelers equipped with FSII injection equipment, ensure equipment is calibrated and maintained according to manufacturer's guidance

4.3.3 Quarterly

4.3.3.1 Fueling Pressure Controls

- Written test protocol should be available for each vehicle and the specific design of pressure control system
- Verify proper operation of primary and secondary control equipment, adjust as necessary and record settings
- Primary pressure control system must be defeated in order to properly test the secondary control setting

4.3.3.2 Water Defense System

- Externally check for satisfactory operation

see Section 6.5.3 Operational Procedures - Quarterly External Check

4.3.3.3 Internal Valve

- Verify proper operation utilizing the “precheck” test

4.3.3.4 Brake Interlock Override Control

- Verify proper operation by activating one of the interlock devices and ensure the vehicle does not move until the override is disengaged

4.3.3.5 Overfill Protection

- Verify satisfactory operation of sensing devices and controls

4.3.4 Semi-Annual

4.3.4.1 Hose Pressure Check

- For hoses operated under pressure and fitted with reusable couplings, pressure test per EI 1540

4.3.5 Annual

4.3.5.1 Filter Differential Pressure (DP) Gauges

- Verify proper operation in accordance with gauge manufacturer's procedures (accuracy must be within +/- 2 PSI) e.g. the Gammon DP gauge instruction manual includes operational check and calibration certificate procedures
- If present, check the DP gauge protection filter element (prevents dirt from entering through the high pressure connection) and replace as necessary

4.3.5.2 Nozzle Fueling Pressure Gauge

- Verify accuracy is within +/- 2 percent of full scale

4.3.5.3 Filter Element Replacement

- see Section 2.8 Filter Element Replacement Criteria
- see Section 6.1 Filter Element Replacement

4.3.5.4 Water Defense System

- Verify operation per manufacturer's recommendations

see Section 6.5.4 Water Defense Systems - Annual Inspection & Test

4.3.5.5 Meter Calibration

- Check accuracy of meters
- Adjust meters to an accuracy of 0.1 percent and verify repeatability of 0.05 percent

  Note: Adhere to calibration accuracy and repeatability tolerances per NIST Handbook 44 where required by state or local regulation

- After calibration is complete, seal meter adjusters/calibrators

4.4 Other References

- ASTM Manual 5 – Aviation Fuel Quality Control Procedures
- ATA Specification 103 – Standard for Jet Fuel Quality Control at Airports

EI 1529 – ***Aviation Fueling Hoses and Hose Assemblies***

EI 1540 – ***Design, Construction, Operation and Maintenance of Aviation Fueling Facilities – Recommended Practice***

EI 1542 – ***Identification Markings for Aviation Fuel Distribution Facilities, Airport Storage and Mobile Fueling Equipment***

EI 1581 – ***Specifications and Qualification Procedures for Aviation Jet Fuel Filter/Separators***

EI 1583 – ***Laboratory Tests and Minimum Performance Levels for Aviation Fuel Filter Monitor)***

EI 1596 – ***Design and Construction of Aviation Fuel Filter Vessels***

EI 1597 – ***Procedures for Overwing Fuelling to Ensure Delivery of the Correct Fuel Grade to an Aircraft***

- NFPA 10 – Standard for Portable Fire Extinguishers
- NFPA 30 – Flammable and Combustible Liquids Code
- NFPA 385 – Standard for Tank Vehicles for Flammable and Combustible Liquids
- NFPA 407 – Standard for Aircraft Fuel Servicing
- MIL-STD-1548 - Intoplane Servicing at Commercial Airports

Chapter 5. Fuel Quality Testing

5.1 API Gravity Test

Warning: Use Personal Protective Equipment (PPE) including eye protection, gloves and appropriate clothing to prevent contact with fuel

5.1.1 Purpose

- Measure the gravity of fuel; a significant change may indicate contamination by another liquid product

5.1.2 Description

- Verify that the observed API Gravity (corrected to 60º F) is within +/- 1º API of the value reported on the bill of lading (BOL) to identify potential contamination by other fuels or products
  - Perform test on every load of aviation fuel that is received at the airport
  - Typical API gravity ranges (@ 60° F)
    - 37 to 51 **Jet Fuel**
    - 64 to 75 **Aviation Gasoline**

5.1.3 Equipment

- ASTM approved API gravity thermohydrometer graduated in increments of 0.1º API is recommended

  Note: (hydrometers that measure relative density and specific gravity are also available but not addressed in this document)

  API Gravity Test Equipment

- Thermohydrometers incorporate both a thermometer and hydrometer in one device

  Thermohydrometer

  - Jet Fuel
    - API gravity range of 29 to 41 (54HL - ASTM classification)
    - API gravity range of 39 to 51 (55HL)
  - Aviation Gasoline
    - API gravity range of 59 to 71 (57HL)
    - API gravity range of 69 to 81 (58HL)

  Note: Verify thermohydrometers are available to cover the observed gravity at the full range of anticipated fuel temperatures throughout the year

- Hydrometer cylinder (clear glass or clear plastic with built in overflow cup to prevent spills are available)
- API gravity correction calculator, aka “whiz wheel”, ASTM tables or online calculator
  see API Gravity Calculator: *TrustedFuel.com > Left Navigation > Calculators*

  API Gravity Calculator (Whiz Wheel)

- Other References
  - ASTM E1 – Standard Specification for Thermometers
  - ASTM E100 – Standard Specification for Hydrometers

5.1.4 Procedure *API Gravity Test*

1. Ensure the range of the thermohydrometer is appropriate for the fuel being tested

2. Verify the condition of the thermohydrometer to ensure it is free from defects: cracks, gaps in mercury, improper alignment of gravity scale (ensure paper scale has not slipped)

Note: Thermohydrometers must not be left in direct sunlight or near heating appliances and should be stored vertically

Note: It is recommended to inventory a back-up thermohydrometer

API Gravity Scale Slippage Indicator

3. Fuel sample and test equipment should be clean and dry

4. Testing should be performed in a location protected from wind to allow the thermohydrometer to stabilize

5. Collect a sample of fuel and place it in the thermohydrometer cylinder

6. Allow the fuel to set to allow air bubbles to disappear

- If any air bubbles remain, remove them by touching with the corner of a clean paper towel

7. Gently lower the thermohydrometer into the fuel in the cylinder

8. After thermohydrometer has settled, depress it about two scale divisions and gently spin and release; this will assist in bringing it to rest floating freely away from the cylinder wall

9. Record observed temperature of the fuel

- After the temperature stabilizes, record to the nearest 1º F
- Lift the thermohydrometer out of the fuel just enough to read the temperature (removing it completely may result in an erroneous temperature reading due to evaporation)

10. Record observed gravity of the fuel

- With the hydrometer scale at eye level, observe the gravity reading at that point on the scale at which the principal surface of the fuel cuts the scale
- Read the hydrometer to the nearest scale division ºAPI and record the value

API Gravity Thermohydrometer Observations

11. Correct observed API gravity of the fuel to 60º F using a temperature correction calculator, aka "whiz wheel", or ASTM tables

- Rotate the disk until the observed hydrometer gravity reading (ºAPI) is aligned with the observed temperature (ºF)
- Read the corrected degrees API at the 60º F arrow

  see API Gravity Calculator:

  TrustedFuel.com > Left Navigation > Calculators

  Note: Technically, atmospheric pressure influences the corrected API Gravity calculation but the impact is mathematically insignificant

  API Corrected Gravity Example

12. Record corrected API gravity

- The API gravity, corrected to 60º F, must agree within +/- 1º API of the value reported on the BOL
- If the gravity is outside of the specified range, re-run the procedure from the beginning
- If the second gravity test confirms previous results, call fuel supplier or see Section 6.4.6 Contaminated/Rejected Load

5.1.5 Other References

- ASTM Manual 5 – Aviation Fuel Quality Control Procedures
- ASTM D287 – Standard Test Method for API Gravity of Crude Petroleum and Petroleum Products - Hydrometer Method
- ASTM D1250 – Standard Guide for Petroleum Measurement Tables
- ASTM D1298 – Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method
- ATA Specification 103 – Standard for Jet Fuel Quality Control at Airports

5.2 Filter Membrane Test

Warning: Use Personal Protective equipment (PPE) including eye protection, gloves and appropriate clothing to prevent contact with fuel

5.2.1 Purpose

General

- Test used to detect particulate contamination in jet fuel using a field monitor
- Two methods are available: colorimetric (color rating) or gravimetric measurement of particulate contamination

  Note: There is no quantitative relationship between gravimetric and color rating test results

Colorimetric Method

- Filter membrane color rating provides a quick and simple qualitative method for detecting contaminant levels in jet fuel
- Color rating can be performed in the field and does not require stringent laboratory procedures
- Membrane color may also be used to assess changes in visual characteristics of jet fuel which may indicate the following
  - Contaminant type
  - Fuel handling system including filtration performance
  - Refinery processing and/or different crude oils

  Note: Colorimetric method is not a substitute for gravimetric procedures to determine particulate contamination

Gravimetric Method

- Uses stringent laboratory procedures to provide a quantitative measurement of particulate matter present in jet fuel

5.2.2 Description

General

- Also known as “Millipore Test” and “Membrane Color Filtration Test”
- Two ASTM test methods are published (D2276 – line sampling or D5452 – laboratory filtration)
- Performing a Filter Membrane test on both the upstream and downstream side of the filter vessel (simultaneous if possible), and observing the membrane colors, will provide comparative data to evaluate the performance of filtration equipment
- Upstream sampling can also be used to monitor the cleanliness of fuel receipts and help identify equipment issues that may be producing particulate contamination
- Perform test monthly downstream of filter vessels or at any time filtration performance is in question

  Note: Customers, such as airlines and military, may require the test to be performed both upstream and downstream of filter vessels

Colorimetric Method

- Membranes are checked for changes in color
- The color on the filter membrane is compared with an ASTM color standard and assigned a rating which provides a standard language for evaluating and communicating filter membrane colors
- Test results are qualitative and provide comparative data that may indicate the need for further investigation (compare color or shade of color to previous results or results from the terminal, on the same fuel)

Gravimetric Method

- Membranes are checked for actual changes in weight
- Results are typically reported in milligrams per liter (mg/L) or milligrams per gallon (mg/gal)

5.2.3 Equipment

General

- Filter Membrane Test Kit compliant with ASTM D2276 that includes a field sampling kit (housing) and plastic field monitor

Millipore Test Kit

- Bonded receiving container (graduated or known capacity)

Note: Permanent sampling connections, with probes projecting into the fuel stream, installed upstream and downstream of the filter vessel are recommended; includes a quick disconnect (with dust plug) that will accept the fitting on the inlet side of the field sampling kit

Colorimetric Method

- Plastic field monitors can be ordered pre-loaded with a membrane pad and support pad or membrane re-fill kits are available that contain both membrane pads and support pads
- Color Rating Guide: ASTM Color Standards rating booklet or optional Color and Particle Assessment Rating Guide (available from Gammon Technical Products, Inc.)

Gravimetric Method

- Pre-weighed test membrane and control membrane pads or matched weight membrane pads must be used to allow for precise measurement of any contaminant collected on the surface of the test membrane pad
- Plastic field monitors can be ordered pre-loaded with a pair of matched weight membrane pads and support pad or matched weight refill kits are available that contain matched weight pairs of membrane pads and support pads

5.2.4 Procedure  *Filter Membrane Test*

General

- Step-by-step procedures and interpretive guidance can be found in various sources (ASTM D2276, ASTM Manual 5, ATA Specification 103 and test kit instruction manuals).
- Test equipment should be clean and in good condition

  Warning: Sampling device must be bonded to both the sampling connection and the measuring container to minimize the risk of static discharge; after fuel flow has stopped, allow all equipment, including the receiving container to stand for a minimum of one minute before removing bonding clips
- Test is performed on fuel taken from ports installed on the inlet and outlet of filter vessels
- Flush (minimum of ½ gallon) and sample (minimum of 1 gallon) volumes should be consistent to provide reasonable comparison between tests
- Measure and record the flush volume and the sample volume (fuel that passed through the membrane pad)

Colorimetric Method

- Known quantity of fuel is drawn from a flowing system and passed through a plastic field monitor containing a 0.80 micron filter membrane pad and support pad
- Membrane Color Ratings
  - Membranes may be rated in either a wet or dry condition; record whether the membrane was wet or dry when rated
  - Rating of the membrane pad should not be performed in direct sunlight
  - If the color shade is between two rating numbers, report the lower number
  - Difference in observed color between dry and wet membranes may be multiple rating numbers apart on the ASTM color standards chart
  - Comparison based on mixed wet and dry ratings should not be made
  - Only dry ratings should be reported when color ratings are used as a communications tool
  - Dry membranes appear lighter in color and typically have a lower color rating
  - Membranes will not change color in the dry state
  - Membranes may be dried by placing on an absorbent paper on a nonflammable heat source free of ignition sources or air dry for approximately 3 hours in a clean environment free of ignition sources

- Interpretation of Results
  - A color rating greater than “2–Dry” or “3–Wet” may indicate a particulate contaminant problem and should be investigated further to evaluate the condition of filtration equipment and identify the source of the darker color
    - Perform an upstream and downstream Millipore test (simultaneous if possible) and observe membrane colors
    - If the membrane color does not improve on the downstream side of the vessel, it is an indication of possible filter element by-pass, particulate contaminants that are smaller than the micron rating of the filter element, or the presence of color bodies in the fuel
    - If fuel color bodies are suspected of causing the membrane color, install two membranes (one on top of the other) in the plastic monitor and follow the standard test method
    - After the test, the same color observed on both membranes is an indication of color bodies in the fuel or potential chemical contamination (i.e. dye, grease, etc.)
    - Depending on differences in the actual color and/or the shade of color compared to previous or typical Millipore test results, additional testing may be considered to determine if the unusual results are related to chemical contamination or color bodies and whether fuel performance characteristics have been affected
    - A darker top membrane indicates that filterable contaminants are present
    - ATA Specification 103 guidance: “If top and bottom membranes have a color rating difference of 2 or less, fuel is to be considered clean and acceptable, if the difference is 3 or greater, conduct a gravimetric analysis”
  - The presence of any visible particles should be immediately investigated

Gravimetric Method

- Known quantity of fuel is drawn from a flowing system and is passed through a plastic field monitor containing two matched weight or pre-weighed 0.8 micron filter membrane pads and support pad
- After running the test, drain fuel from the plastic field monitor but do not open
- Forward the field monitor to a qualified lab for weighing according to procedures found in ASTM D2276
- Results should be reported to the nearest 0.01 mg/L or mg/gal
- ATA Specification 103 guidance: "Fuel is unacceptable if gravimetric test (ASTM D2276) results exceed 2.0 mg/gal or 0.5 mg/L based on test sample size taken"

5.2.5 Other References

- ASTM D2276 – Standard Test Method for Particulate Contamination in Aviation Fuel by Line Sampling
- ASTM D5452 – Standard Test Method for Particulate Contamination in Aviation Fuels by Laboratory Filtration
- ASTM Manual 5 – Aviation Fuel Quality Control Procedures

GamGram 6 – ***Anatomy of a Sampling Connection***
GamGram 13 – ***The Mystery of the Color Rating***
GamGram 25 – ***Filter Membrane Testing and Rating***

5.3 Free Water Test

Warning: Use Personal Protective Equipment (PPE) including eye protection, gloves and appropriate clothing to prevent contact with fuel

5.3.1 Purpose

- Detect the presence of free water (ranging from very low levels entrained/suspended in fuel to bulk water in storage tanks)

5.3.2 Description

Free Water Test Kits

- Detect the presence of entrained/suspended free water in jet fuel in concentrations that are not visible to the naked eye (typically less than 30 parts per million PPM)
- Typically used downstream of filtration to monitor performance; however, it may be used as a quick check for free water at any point in the fuel distribution system
- Perform test monthly downstream of filter vessel or at any time filtration performance is in question

Water Detection Paste

- Detect the presence of bulk water in storage tank bottoms

5.3.3 Equipment

Free Water Test Kits

- Clean, dry sampling container
- Testing device containing water sensitive powder or paper that indicates the presence of free water by a color change (becomes more evident with increasing concentration of free water)

Velcon Hydrokit

Water Detection Paste

- Water sensitive paste that indicates the presence of free water by a color change
- Calibrated stick or gauge tape of sufficient length to reach from the gauge hatch to the bottom of the tank

5.3.4 Procedure

Free Water Test Kits

Important: Water sensitive media used in these kits are subject to special handling and shelf life

- Step-by-step procedures and interpretive guidance can be found in the test kit instruction manuals provided by the manufacturer
- Collect fuel sample in clean, dry container
- Record the concentration, in PPM, of any entrained/suspended free water detected (maximum allowable limit of 15 PPM downstream of filtration is generally recommended)
- Velcon Hydrokit  ***Free Water Test***
    - Test is performed on a static sample
    - No specific ASTM standard for this procedure
    - Fuel is added to a vial containing water sensitive powder
    - Powder turns pink if free water is present
    - Two kits available: 15 PPM and 30 PPM sensitivity
- Shell Water Detector
    - Test is performed on a static sample
    - No specific ASTM standard for this procedure
    - A specified quantity of fuel is drawn through a pad treated with a water sensitive chemical
    - Pad color changes to a progressively more noticeable green color as the free water content increases
    - With a 5 ml sample, a distinct green color is observed at 30 PPM

- Gammon Aqua-Glo Water Detection Kit
  - Test is performed on a sample is drawn from a flowing fuel system
  - Procedure is addressed by ASTM D3240
  - A specified quantity of fuel is drawn through a pad treated with a water sensitive chemical
  - Pad is viewed under ultraviolet light and compared to a known standard
  - Test covers a range from 0 to 12 PPM and measures free water in increments of 1 PPM
  - Ensure test results are documented

Water Detection Paste

Important: Paste does not respond to dissolved water or entrained/suspended free water and standard paste will not detect free water if it contains a significant amount of FSII additive; a special paste is available for fuels containing FSII additive

- Apply thin coat of paste to a gauge tape or stick
- Lower tape or stick until it lightly touches the bottom of the tank and hold for several seconds
- Remove and observe any color change of the paste

Note: Any bulk free water detected should be removed

5.3.5 Other References

- ASTM Manual 5 – Aviation Fuel Quality Control Procedures
- ASTM D3240 – Standard Test Method for Undissolved Water in Aviation Turbine Fuels
- ATA Specification 103 – Standard for Jet Fuel Quality Control at Airports

5.4 Fuel System Icing Inhibitor (FSII) Test

Warning: Use Personal Protective Equipment (PPE) including eye protection, gloves and appropriate clothing to prevent contact with fuel

5.4.1 Purpose

- Measures the concentration of FSII additive in jet fuel

Tech Topic – FSII Additive

5.4.2 Description

- ASTM test method used to verify the concentration of FSII additive in the jet fuel is between 0.10 and 0.15 volume % per ASTM D1655
- Perform test monthly on jet fuel inventory; it is also recommended that FSII testing be conducted on fuel receipts

see Section 6.4 Operational Procedures - Receipt of Fuel

5.4.3 Equipment

FSII additive test kits can be purchased through aviation fuel equipment distributors and typically include the equipment below:

FSII Additive Test Equipment (B2 Kit)

- Equipment used to collect and mix specified quantities of fuel and water
- Refractometer
  - Used to determine the concentration of the FSII additive in the jet fuel by measuring the refractive index of a water extract
  - Currently, the following refractometers are approved for this test; refer to latest edition of ASTM D5006 for updates
    - HB Refractometer – Analog refractometer providing direct read DiEGME concentration (automatically temperature compensated within the range of 18 to 35C)
    - Brix Refractometer – Analog refractometer utilizing a Brix scale that requires a conversion calculation or chart to determine the DiEGME concentration (may or may not be automatically temperature compensated
    - MISCO Jet Fuel Refractometer – Digital refractometer providing direct read DiEGME concentration (automatically temperature compensated within the range of 10 to 45C)
    - Gammon HB2D Refractometer – Digital refractometer providing direct read DiEGME concentration (automatically temperature compensated within the range of 10 to 40 C)

5.4.4 Procedure *FSII Concentration Test*

Specified quantities of fuel and water are mixed together in order to extract the entire volume of additive out of the fuel and into the water. Several drops of the water extract are placed on the prism face of the refractometer and the volume % is read directly from a scale viewed through the eyepiece. Step-by-step procedures and interpretive guidance can be found in various sources (ASTM D5006)

Note: If a Brix scale refractometer is used, see the referenced ASTM test method:

- modification of the extraction procedure
- details of the temperature correction procedure
- conversion from the Brix scale to volume %.

General

- Sampling points include transport truck manifold or dome hatch, in-line (millipore port), storage tank, or refueler tank
- Ensure sample container is clean and dry container
- Best sample source is from a pressurized stream such as the fuel nozzle
- Ensure sample is free of visible free water
- Distilled or deionized water is preferred, but potable water may be used
- Calibrate refractometer (set to zero) using the same water being used for the extraction; refer to calibration instructions from the manufacturer

Refractometer Scale

- Extraction, calibration and measurement should be done at ambient conditions
- Accuracy is improved if the temperatures of the refractometer, water, fuel sample and ambient temperature are in equilibrium; and within the specified temperature range of the refractometer per the manufacturer
- Failure to vigorously agitate for the specified time can result in false readings
- The water extract placed on the refractometer should be free of any jet fuel
- Ensure test results are documented

- Field testing additive concentration directly off the transport requires special procedures; due to injection system design/operation and variances that occur during injector shut down, the last gallons of fuel loaded into a trailer compartment, and isolated in the manifold piping, may not be representative of the fuel in the compartment (this may result in erroneous additive concentration test results)
  - A composite sample pulled from the trailer dome hatch will be representative of the entire compartment

    Warning: Ensure proper fall protection for fall arrest
  - If this is not practical from a safety or operational standpoint, a sample may be pulled from the trailer manifold piping
    - Clear the line fill from the shortest manifold line to minimize the quantity of waste fuel
    - Refill the empty manifold piping with fuel from the compartment
    - Pull a sample of fuel from the refilled manifold line

5.4.5 Other References

- ASTM D5006 – Standard Test Method for Measurement of Fuel System Icing Inhibitor in Aviation Fuels
- ASTM D1655 – Standard Specification for Aviation Turbine Fuels

5.5 White Bucket Test

Warning: Use Personal Protective Equipment (PPE) including eye protection, gloves and appropriate clothing to prevent contact with fuel

5.5.1 Purpose

- Ensure aviation fuel is free from visible contaminants

5.5.2 Description

- Subjective visual inspection of fuel sample taken from transport truck, storage tank or filter vessel; results are evaluated against standard rating scale and against historical observations
- Frequency
  - Every fuel receipt
  - Daily on storage tank sumps (prior to first fuel sale)
  - Daily on filter vessel sumps (prior to first fuel sale)
  - At least monthly on overwing fuel nozzle sample

5.5.3 Equipment

- White porcelain bucket of at least two gallon capacity equipped with a static bonding cable
- A coin with well defined features to help identify haze in fuel

5.5.4 Procedure  *White Bucket Test*

- Collect representative sample from tank sumps (under full flow) and from filter vessel sumps (under pressure); sampling under full flow/pressure will help flush debris from system and in the case of filter vessels will prevent air from being introduced into the vessel

  Warning: Use caution when sumping under pressure or full flow to prevent splash or spill

  - Ensure white bucket is clean and in good condition

    Warning: Minimize static discharge risks by using metal bucket with bonding cable; do not use plastic buckets

  - Clear sump line fill prior to pulling sample

    see Line Fill Calculator: *TrustedFuel.com > Left Navigation > Calculators*

    Warning: Use care when opening a pressurized sample drain to prevent a splash or spill

  - Fill bucket with approximately one gallon of fuel
  - Let sample settle for about one minute to remove air bubbles
    - Air bubbles may cause a hazy appearance but will typically clear within one minute
  - Swirl the bucket gently to bring any particulates to the center for easier detection
  - Fuel producing an unfamiliar odor may be an indication of problems and should be investigated

- Inspect sample for contaminants
  - Free water (a drop of food coloring will assist in detecting free water by dissolving into free water, if present)
    - Water droplets
    - Hazy fuel (drop coin in sample to help detect haze in the fuel; features of the coin will be clearly visible if no haze is present)
    - Cloudy fuel (at this point you can't see the coin at all)
  - Particulates
    - Rust, filter media, hose material, gaskets, metal shavings, etc.
  - Surfactants
    - Soapy, sudsy material on surface
    - Lacy like material at fuel/water interface
    - Brownish colored water

    Note: A persistent haze in the fuel is an indication that surfactants may be present and should be investigated further
  - Microorganisms
    - Slimy or matted material floating or suspended in the fuel
    - Dark colored water
    - Pungent odor similar to rotten eggs

    Note: Microbial activity displays similar visual characteristics of surfactants; testing may be required to determine the type of contamination
  - Other fuels
    - Unfamiliar color
    - Color of jet fuel can range from water white to light straw or amber
    - Other colors may be an indication of potential contamination by other products or unapproved additives

- Investigate source of any observed contamination or inconsistencies compared to historical observations and take appropriate action
- Record the sump observation using the appearance rating table below

Note: The initial observation should be recorded and it is recommended to continue sumping until a "1A" rating is observed

White Bucket Rating Guide

Particulate Appearance	Rating	Description
Clear	1	No visible particulates, silt, sediment, dye, rust, solids or unusual color
Slight Particulate	2	Some fine to small size particles
Particulate	3	Many small particles floating or settled on the bottom
Dirty	4	Discoloration or many particles floating or settled on the bottom

Moisture Appearance	Rating	Description
Bright	A	No free water (haze, droplets or liquid)
Hazy	B	Fine water droplets dispersed throughout the sample (haze may disappear if the sample warms, but must be reported)
Cloudy	C	Sample appears cloudy or milky
Wet	D	Droplets or a layer of water on the side or bottom
Surfactant	E	Slime on bottom or at the fuel/water interface or a lacy or soapy material floating in or on the surface

5.5.5 Other References

- ASTM Manual 5 – Aviation Fuel Quality Control Procedures
- ATA Specification 103 - Standard for Jet Fuel Quality Control at Airports

GamGram 21 – ***Is it Good or Bad Fuel – How Can You Tell?***

5.6 Jet Fuel Conductivity Test

Warning: Use Personal Protective Equipment (PPE) including eye protection, gloves and appropriate clothing to prevent contact with fuel

Warning: To prevent static discharge between a charged fuel and a conductive probe inserted into a tank, the appropriate safety precautions of bonding and waiting for charge dissipation should be observed

5.6.1 Purpose

- Static electricity can be generated by the movement of two dissimilar surfaces across each other; such as fuel moving through a pipe, hose or filter
- The rate at which this static charge dissipates is proportional to the fuel's conductivity
- Electrical conductivity additives (aka, static dissipating additives) have been developed to increase the electrical conductivity properties of jet fuel which allows accumulated static charge on the fuel to dissipate at a faster rate
- Note: Use of electrical conductivity additives may cause reductions in the MSEP rating (ASTM D3948) of jet fuel

5.6.2 Description

- Two ASTM test methods are published in the D2624 Standard:
  - Portable meters used to measure conductivity of fuel samples
  - In-line meters for the continuous measurement of fuel conductivity
- The portable meter method will be addressed in this section

5.6.3 Equipment

- Currently, the following portable equipment is approved for this test; refer to the latest edition of ASTM D2624 for updates
  - EMCEE Model 1152 Meter
  - D-2 Inc. Model JF-1A-HH Meter

5.6.4 Procedure

- Perform conductivity testing per guidance found in ASTM D2624 or from the equipment manufacturer
  - The conductivity meter probe is immersed in the fuel sample and the conductivity is read directly from the meter
    - Conductivity is measured in conductivity units (CU), which are defined as pico Siemens per meter (pS/m)
  - Prior to performing a fuel conductivity test, the equipment should be clean, dry and calibrated per procedures found in ASTM D2624 or from the equipment manufacturer

    Important: Conductivity cells and measuring probes or sensors must be kept free from water contact which can significantly affect accuracy of test results
  - Fuel conductivity measurements should be made at the sampling location

    Important: If sampling for subsequent analysis, be aware that test results are known to be sensitive to trace contamination from sampling containers (sampling container preparation addressed in ASTM D2624)
  - Conductivity measurements should be made as soon as possible after sampling and preferably within 24 hours

    Important: The conductivity of fuels containing static dissipator additives is affected by sunlight and other strong light sources; samples in clear glass containers can experience significant conductivity loss within five minutes of sunlight exposure
  - Report the electrical conductivity of the fuel and the fuel temperature at which the measurement was made

    Note: Electrical conductivity of fuel varies significantly with temperature (typically as the temperature of the fuel increases, the conductivity of the fuel increases); that relationship differs for various types of aviation fuel and can also be affected by clay filtration and materials such as static dissipating, corrosion inhibitor, and fuel system icing inhibitor type additives
  - ASTM D1655 provides guidance for static dissipating additive dose rates and acceptable conductivity ranges (pS/m) for fuel containing the additive

5.6.5 Other References

- ASTM D1655 – Standard Specification for Aviation Turbine Fuels
- ASTM D2624 – Standard Test Methods for Electrical Conductivity of Aviation and Distillate Fuels
- ASTM D4306 – Practice for Aviation Fuel Sample Containers for Tests Affected by Trace Contamination

JIG Bulletin No. 25 – *Jet Fuel Conductivity*

Chapter 6. Operational Procedures

6.1 Filter Element Replacement

Filtration systems must be continuously monitored to ensure compliance with performance standards and service life guidance see Section 2.8 Filtration – Filter Element Replacement Criteria

Many filtration systems have been designed to meet various airport applications (some vessels are designed to accept a variety of filter elements). Manuals are available from the filter vessel manufacturers that address different configurations, operating conditions and step by step instructions for element changeout. Because of the diversity of filtration systems, this section will cover general guidance around filter element replacement.

6.1.1 General Guidance

- Follow manufacturer's element changeout procedures
  - Velcon website provides instructions for various vessels
  - Facet will provide instructions for specific vessels on request

6.1.2 Ordering Replacement Elements

- The following information should be provided to the supplier to ensure elements are "fit for purpose"
  - Desired functionality see Chapter 2 Filtration
  - Fuel type/grade (aviation gasoline, jet fuel or jet fuel with FSII additive)
  - Filter vessel model number
  - Filter vessel serial number
  - System flow rate
  - Current element type and quantity installed

Note: Customers (e.g., airlines, military) may have specific requirements related to latest edition of EI qualified filter vessels and elements

6.1.3 Filter Element Shelf Life

- Shelf life is based on the date of manufacture which is typically indicated on the element
- General storage guidance to maximize shelf life includes:
  - Keep elements in original packing
  - Store in a dry environment away from the sun
  - Avoid extreme temperatures and moisture
- If stored properly most elements should be suitable for use up to five years
- Some elements have a recommended shelf life of only one year
- Water absorbing monitor elements should be installed within two years
- All elements should be thoroughly examined (gaskets, seams, end cap adhesive, etc.) prior to use

  Note: Consult element supplier/manufacturer for additional information and specific guidance

6.1.4 Drain the Vessel and Remove Old Elements

- Drain the vessel per manufacturer's guidance

  Procedure for Draining the Vessel

- When removing old elements, inspect for signs of damage or microbial activity
  - Separator elements

    Removing Separator Cartridges

  - Coalescer elements

    Removing Coalescer Cartridges

6.1.5 Inspect the Vessel Interior

- Verify the vessel interior is clean and free of water, sediment, evidence of microbial growth or other contamination

Cleaning the Vessel

- Inspect interior coating of the vessel and repair as necessary

6.1.6 Install New Filter Elements

- Follow manufacturer's installation instructions; elements must be properly installed and the vessel must be operated properly to ensure designed performance is achieved
- Filter elements must be matched by manufacturer and edition (e.g., do not mix Velcon and Facet elements or mix different edition elements)
- When unpacking new elements, break the polyethylene bag open at the end but leave the bag in place for handling during installation; do not touch the surface of the filter element media
- Tighten elements per manufacturer's torque recommendations to ensure proper seal
- If desired, verify options and follow procedures for inspection, cleaning and re-use of Teflon coated separators; instructions are available from the element manufacturer

Cleaning Teflon Coated Separators

- If using separator elements containing synthetic media or paper separator elements, follow specific service life guidance from the manufacturer

- For EI qualified filtration systems, verify elements have been qualified for use in the vessel
- For non EI qualified filtration systems, verify desired effluent standards are met

Installing the Coalescers

Installing the Separators

Warning: Follow recommended handling guidance to avoid compromising performance of the elements

Coalescing – Graping

Warning: Follow recommended installation protocol to avoid damaging elements or compromising performance

Coalescing – Smoking

6.1.7 Close and Refill the Vessel

- Close and secure vessel per manufacturer's guidance

Closing and Refilling the Vessel

- Slowly refill the vessel to avoid static discharge and possible flash fire/explosion
- Inspect system for leaks and repair as necessary
- Circulate product through the filter vessel per manufacturer's recommended procedure
- Check and record differential pressure (DP); there should be an indication of a pressure drop across the vessel (manufacturer can provide guidance on expected DP immediately after element changeout)

Warning: Low or no DP at normal flow may indicate compromised performance and should be investigated

- Records should be maintained to document element and vessel inspection results, element and vessel data, change date and post-installation check results

Filter Vessel Information Form

- Post the month and year of change on or near the filter vessel

6.1.8 Other References

o ATA Specification 103 – Standard for Jet Fuel Quality Control at Airports

GamGram 15 – ***Filter Separator Fires***

Monitor Changeout Procedure

6.2 Misfueling Prevention

Misfueling is defined as delivering the incorrect type/grade of fuel into an aircraft. Misfueling can result in engine failure that could be catastrophic if the failure occurs during flight. Following are some examples:

- Jet Fuel ➔ Piston Engine (spark ignition)
  - Total engine failure due to knock damage
- Aviation Gasoline ➔ Turbine Engine
  - Vapor lock and engine failure due to fuel starvation; although many turbine engines are capable of operating on aviation gasoline, such operation is strictly controlled per the Pilot's Operating Handbook (POH) / Airplane Flight Manual (AFM)
- Aviation Gasoline ➔ Piston Engine (compression ignition, i.e. diesel)
  - Fuel ignition failure
- Jet Fuel (no FSII) ➔ Aircraft Requiring FSII
  - Engine failure due to fuel starvation caused by ice blocking fuel lines or filters

Because of the serious consequences of misfueling, a comprehensive prevention program that includes procedures, equipment, training and documentation should be in place. A thorough evaluation of industry guidance should be used to develop a site specific program.

6.2.1 Procedures

Vigilance is required during various stages of fuel handling at the airport to prevent cross contamination of fuels

- Receipt of fuel into storage see Section 6.4 Operational Procedures – Receipt of Fuel
- Transfer of fuel from the fuel storage facility into the refueler
  - Use grade selective couplings
  - Follow site specific procedures to ensure products remain segregated
- Dispensing fuel into aircraft
  - Confirm fuel order before fueling begins
    - Written Order – signed fuel order forms recommended or
    - Verbal Order – repeat back to customer
  - Verify fuel order matches the aircraft fuel grade wing decal; if not, obtain written fuel order confirmation
  - For jet fuel orders, confirm Fuel System Icing Inhibitor (FSII) additive requirement
  - Consult aircraft ground service guide as necessary

EI 1597 – *Procedures for Overwing Fuelling to Ensure Delivery of the Correct Fuel Grade to an Aircraft (see Annex A & B)*

  - Do not assume fuel grade required by aircraft
    - Visual appearance alone cannot be used to positively identify the grade of fuel required by the aircraft
    - Existing aircraft are being converted from spark ignition piston engines (aviation gasoline) to compression ignition engines (diesel fuel)
    - Aircraft previously equipped with spark ignition piston engines that used aviation gasoline are now being produced with turbine engines that use jet fuel

6.2.2 Equipment

- Physically segregated systems (tanks, piping, filtration, etc.) dedicated to a single type/grade product; in multi compartment tanks all compartments must contain the same type/grade product
- Signs, Placards & Labels
  - Fuel Storage Facility
    see Section 3.2.9 Fuel Storage Facility – Signs, Placards & Labels
  - Refuelers
    see Section 4.2.9 Refueler – Signs, Placards & Labels
- Aircraft fueling nozzles/spouts
  - Fuel Storage Facility
    see Section 3.2.11 Fuel Storage Facility – Fuel Nozzles
  - Refuelers
    see Section 4.2.13 Refueler – Fuel Nozzles
  - Note: If a smaller non-selective jet fuel spout is required, additional procedures and controls are necessary
- Grade Selective Couplings
  - Grade selective couplings at the transport off-load point will help prevent the wrong grade of fuel from being delivered into storage
  - Grade selective couplings for the transfer of fuel into refuelers will help prevent the incorrect grade of fuel from being loaded into fueling vehicles

6.2.3 Training

- Each facility should develop policies and procedures to address various site specific fueling scenarios (unattended fueling, standing orders, turbine engine aircraft that will not accept the wider jet spout, aircraft with no fuel grade wing decals, etc.)
- Include all employees involved in any aspect of fuel ordering and aircraft fueling in both initial and recurrent training

6.2.4 Other References

- ATA Specification 103 – Standard for Jet Fuel Quality Control at Airports

EI 1542 – ***Identification Markings for Aviation Fuel Distribution Facilities, Airport Storage and Mobile Fueling Equipment***

EI 1597 – ***Procedures for Overwing Fueling to Ensure Delivery of the Correct Fuel Grade to an Aircraft – Recommended Practice***

GamGram 20 – ***Recipes for Disaster***

GamGram 29 – ***Preventing Misfueling***

6.3 Fuel Nozzle Screen Inspection *Nozzle Screen Inspection*

The nozzle screen is the last line of defense protecting aviation fuel from particulate contamination prior to entering the aircraft. A missing or damaged nozzle screen eliminates the opportunity to catch particulate contamination that may be introduced downstream of filtration or as a result of defective or damaged filtration.

- Aircraft fueling nozzles should be equipped with 100 mesh screens

Fuel Nozzles and Screens

- Nozzle screens should be checked monthly for damage or presence of debris
- Nozzle screens are to be replaced if damaged and cleaned if debris is present
- If debris is discovered, investigate the cause and take appropriate corrective action
- Types of debris could include rust, sand, sediment, seal or gasket material, Teflon tape, small pieces of fueling hose, metal shavings, etc.

6.4 Receipt of Fuel

Proper receipt procedures are required to detect any indications of fuel contamination prior to receiving fuel into inventory. Fuel appearance should be visually free of free water, sediment and suspended matter. In addition to field QC testing, procedures should also address fire safety, equipment condition and operating safety, environmental protection, misfueling prevention, etc. The results of all fuel receipt procedures should be recorded.

Record of Receipt from Transport Truck

6.4.1 Review Fuel Delivery Documentation

- Check the bill of lading (BOL) to confirm proper fuel type/grade, quantity and loading API gravity
- Confirm receipt of a Certificate of Analysis (COA), certifying that the product meets specification requirements of ASTM D1655 for jet fuel or ASTM D910 for aviation gasoline (document should be supplied by the terminal where the fuel was loaded)
- BOL date should be within six months of COA date
- Verify acceptable prior cargo, or cleaning certificate, if transport is not dedicated to fuel being delivered

Transport Cross Loading Chart

- For jet fuel pre-treated with Fuel System Icing Inhibitor (FSII) additive
  - Verify the presence of the FSII additive is indicated on the Bill of Lading (BOL)
  - Verify the quantity of FSII additive in the fuel is documented
  - Verify the FSII additive concentration (gallons of additive/gross gallons of fuel) is within the ASTM specification (0.10 to 0.15 volume %)
  - If the presence of FSII additive or the quantity of additive in the load of fuel is not available, contact the fuel supplier
  - In addition to verifying the documented FSII additive concentration, it is recommended that the additive concentration be verified prior to dispensing fuel

see Section 5.4 Fuel Quality Testing - FSII Test

6.4.2 Prepare for Fuel Delivery

- Sump receiving tank to detect and remove any water or particulate contaminants
- Line up valves to receive fuel into the correct tank
- Allow transport to settle for a minimum of ten minutes with the internal valves open
- Inspect transport offloading hoses and fittings for cleanliness

6.4.3 Pre Receipt Quality Assurance Testing

- Perform the **white bucket test** on each compartment of the transport to detect possible visible fuel contamination
  see Section 5.5 Fuel Quality Testing - White Bucket Test
  - If visible contamination is detected during the sumping operation, it may be necessary to re-sump the contaminated compartment
  - Should the sump sample not clear after approximately five one gallon samples from any single compartment, the shipment should be rejected
- Perform the **API gravity test** (corrected to 60º F) and verify it is within +/- 1º API of the value reported on the BOL to identify potential contamination by other fuels or products

API Gravity (Density)Tutorial

6.4.4 During Fuel Receipt

- Monitor the differential pressure (DP) across all receiving filter vessels
- Monitor system for leaks
- As needed, perform filter membrane test and free water check
  see Section 5.2 Fuel Quality Testing – Filter Membrane Test
  see Section 5.3 Fuel Quality Testing – Free Water Test

6.4.5 After Fuel Receipt

- Allow the fuel farm storage tank to settle (one hour per foot of product height for jet fuel and fifteen minutes per foot of product height for aviation gasoline)
- After settling, and prior to dispensing fuel, the receiving tank shall be sumped to detect and remove any water or particulate contaminants
- If the FSII additive concentration (jet fuel only) was not verified by a field test prior to offloading the transport, it is recommended that field testing be conducted prior to dispensing fuel

6.4.6 Contaminated/Rejected Load

The following procedures should be followed in the event that a load of aviation fuel is determined to be unacceptable due to contamination, quality issue or other reasons.

- Documentation
  - Contact the fuel supplier with the following information
    - Name of customer
    - Date of shipment
    - Product
    - Bill of Lading number
    - Certificate of Analysis date
    - Truck/Trailer number
    - Prior cargo
    - Justification for rejecting the load (listed below)
  - Carrier's documentation of pre-loading and post-loading inspections
  - Copies of the supporting documents: bill of lading (BOL), certificate of analysis (COA), delivery ticket and prior cargo documentation) should be retained
  - Reasons for rejection
    - Failed white bucket test
      see Section 5.5 Fuel Quality Testing - White Bucket Test
    - Variation in API Gravity
      see Section 5.1 Fuel Quality Testing - API Gravity Test
    - FSII Additive Concentration
      see Section 5.4 Fuel Quality Testing - FSII Test
    - Prior Cargo

Transport Cross Loading Chart

6.4.7 Other References

- ASTM D5006 – Standard Test Method for Measurement of Fuel System Icing Inhibitor in Aviation Fuels
- ASTM Manual 5 – Aviation Fuel Quality Control Procedures
- ATA Specification 103 – Standard for Jet Fuel Quality Control at Airports
- NFPA 407 – Standard for Aircraft Fuel Servicing

6.5 Water Defense Systems

The design and functionality of coalescer/separator (two-stage) filtration requires a water defense system to be installed that will stop fuel flow or alarm operating personnel when activated by a high water level in the filter vessel sump.

6.5.1 Basic Designs

- Float Operated Systems
  - Floats are designed to sink in fuel and float in water (based on density of water compared to aviation fuels)
  - When water reaches a high level in the sump, the float rises and activates a pilot valve or electrical switch to stop fuel flow
  - Accumulated water must be drained from the sump to allow fuel flow to resume
- Electric Probe Operated Systems
  - Probes are designed to detect changes in electrical conductivity (water is highly conductive compared aviation fuels)
  - When water reaches a high level in the sump, the probe senses the water and activates a control valve or electric switch to stop fuel flow
  - Accumulated water must be drained from the sump to allow fuel flow to resume
- System design should include provisions for an operational check in accordance with manufacture's procedures
  - Verify that the "float" floats in water or the probe senses water
  - Verify that the fuel shutoff mechanism or alarm functions when activated

6.5.2 Cautions

- Special attention is required if water is injected into sump to check the operation of the water defense system
  - Always inject a measured amount of water based on volume of sump
  - All injected water must be recovered (compare against injected amount)
  - After testing, re-circulate (or for dispensers clear the line fill downstream of the filter vessel) to ensure all water is removed
  - Never test water defense system while fueling aircraft

6.5.3 Quarterly External Check

- Verify satisfactory operation of the water defense system by physically raising the float or float ballast on float type systems or injecting water into the probe on probe type systems to confirm proper system shutdown
- Note: Manual testers on some float operated pilot valves only check the operation of the control valve and not the buoyancy of the float
- System may also be checked by injecting water into the filter vessel sump see Section 6.5.2 Operational Procedures – Cautions
- Repair any operating deficiencies prior to placing equipment back in service

6.5.4 Annual Inspection and Test

- Float Operated Systems
  - Confirm satisfactory performance by verifying that fuel flow stops when the float is in the raised position
  - Confirm buoyancy of the floats that are not equipped with external ballasts
  - Repair any operating deficiencies prior to placing equipment back in service
- Electric Probe Operated Systems
  - Confirm satisfactory performance by verifying that the fuel flow stops when water makes contact with the probe
  - Check probe assemblies, and clean as needed per manufacturer's instructions (contaminants on the probe may cause malfunction)
  - Repair any operating deficiencies prior to placing equipment back in service

6.5.5 Other References

- ATA Specification 103 – Standard for Jet Fuel Quality Control at Airports
- ASTM Manual 5 – Aviation Fuel Quality Control Procedures

GamGram 10 – ***Filter Separator Controls: Part 1 - Automatic Confusion***

GamGram 11 – ***Filter Separator Controls: Part 2 – Testing***

GamGram 12 – ***Slug Valves***

GamGram 24 – ***Slug Valve Flow and Control***

GamGram 58 – ***We Must All Agree - A Water Defense System is Essential***

6.6 Record Keeping

Record keeping is an essential part of any aviation fuel quality assurance program. Without documentation, no matter how precisely and thoroughly activities are actually performed, there is no evidence of completion. Records should be maintained to document the following:

- Fuel receipts and fuel quality testing
- Inspection and maintenance on fuel storage facilities and refuelers
- Personnel quality assurance training

6.6.1 General

- Necessary to manage the various components of the fuel handling operation
- Provides historical and comparative data for diagnostic and maintenance work
- May be required to meet industry standards and regulatory requirements
- Must be completed by the person performing the task or the person responsible for performance of the task
- Should contain the identification of the person performing the task or person responsible (legible signature, initials or employee ID number)

6.6.2 Types of Records

- Facility Operations
  - Fuel receipt – ensure quality of fuel received and proper transfer procedures
  - Field testing – fuel quality and equipment performance
  - Filtration – filter vessel components, condition, performance, element replacement
  - Fixed fueling equipment – condition and performance testing
  - Mobile fueling equipment – condition and performance testing
  - Fuel storage facilities – inspections and cleaning
  - Document daily, weekly, monthly, quarterly, semi-annual and annual inspections and testing
  - Upon completion of facility and equipment inspections, record results using the following condition codes (per ATA Specification 103)
    - S = Indicates satisfactory
    - C = Indicates comment in the remarks section (any corrective actions must be documented and dated)
    - N/U = Indicates unit not used
    - N/A = Indicates item not applicable
  - Sump sample ratings should be used to record observations see Section 5.5 Fuel Quality Testing - White Bucket Test
  - Additional or modified facility operating records may be required based on local circumstances

- Training
  - Records are used to track and document skill set competency
  - Initial and recurrent training to ensure proper and consistent performance
  - Industry required based on type and size of operation (e.g. CFR Part 139)
  - Classroom , on line and on the job to address specific and practical knowledge
  - Equipment operating/maintenance guidance to promote equipment reliability and ensure safe operation
  - Environmental protection (e.g. SPCC plan)
  - Additional or modified training and records may be required based on local circumstances

6.6.3 Record Retention

- Facility and equipment Inspection record retention guidance per ATA Specification 103
  - Fuel receipt records - 12 months
  - Daily, monthly, quarterly, semi-annual, and annual equipment check records – 12 months
  - Filter change records – 36 months
  - Tank Inspection and cleaning records – Indefinitely
- Modified retention schedules may be required based on local circumstances

6.6.4 Other References

- ATA Specification 103 – Standard for Jet Fuel Quality Control at Airports
- NATA – Refueling and Quality Control Procedures for Airport Service and Support Operations

6.7 Calibration

A variety of equipment and tools are used to support fuel handling operations. For example, devices such as nozzle pressure gauges are used to ensure proper fueling system operation and to prevent damage to aircraft. Gauges to measure differential pressure are used to assess the condition of filter elements. Accuracy of this equipment is important in evaluating performance and making decisions related to repair and maintenance, therefore a calibration program is critical. This program should also include certification of tools such as master gauges, torque wrenches, ohm meters etc.

Calibration is the setting or correcting of a measuring device, usually by adjusting it to match or conform to a device of known correctness.

6.7.1 Equipment / Tools To Be Calibrated

- Identify ***equipment*** to be included in a calibration program e.g.
  - Custody transfer meter
  - Fueling pressure gauges
  - Differential pressure gauges
- Identify ***tools*** to be included in calibration program e.g.
  - Thermohydrometers
  - Densitometers
  - Jet fuel conductivity meter
  - Multimeter / ohm meters
  - Torque wrenches
  - Master gauges
- Record equipment description, serial number, calibration date, next calibration due date etc.

6.7.2 Calibration Procedures

- Calibration services may be available through the original tool manufacturer or by third party vendors
- In some cases, a duplicate device used only for reference and accuracy verification, may be used as part of a calibration program (e.g. thermohydrometer)
- Some equipment manufacturers provide calibration guidance (e.g. Gammon Gauge GTP-534 Series – "Operational Check and Calibration Certificate")
- Meter calibration may be covered under a local Weights and Measures inspection program
- Calibration and equipment certification documentation should be part of a record keeping program

6.7.3 Frequency

- Various industry standards provide guidance on calibration frequency and tolerance requirements for different types of equipment; some examples are listed below:

Standards

- ATA Specification 103 – Standards for Jet Fuel Quality Control
- National Institute of Standards and Technology (NIST) Handbook 44 – Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices

  http://www.nist.gov/publication-portal.cfm# (search By Title: "NIST HB 44")

Equipment

- see Section 4.3.1.7 Daily – Nozzle Pressure (monitor)
- see Section 4.3.3.1 Quarterly – Nozzle Pressure Controls (check)
- see Section 4.3.5.2 Annually – Nozzle Pressure Gauges (verify accuracy)
- see Section 4.3.2.2 Monthly – Bonding System Continuity (check)
- see Section 4.3.5.1 Annually – Filter Differential Pressure Gauges (verify accuracy)
- see Section 4.3.5.5 Annually – Custody Transfer Meters (verify accuracy)

Glossary of Terms

Absorption – to suck up or take up e.g. a sponge absorbs water; a filter monitor element (super absorbent polymer) absorbs water; see adsorption.

Additives – Fuel soluble compounds, added in small quantities, used to impart new properties to a product or to improve or maintain a property which it already possesses. Additives and their use must meet the requirements of the applicable ASTM aviation fuel specification. See following list of additives:

- Antioxidant
- Biocidal
- Color Dye
- Corrosion Inhibitor
- Electrical Conductivity
- Fuel System Icing Inhibitor
- Leak Detection
- Lubricity Improver
- Metal Deactivator
- Plus One Hundred
- Tetraethyl Lead

Adsorption – As it relates to clay treatment of jet fuel, adsorption is a separation method where surfactants (surface active agents) are separated from jet fuel by "adhering to" or "adsorption on" clay elements; see absorption.

Advisory Circular (AC) – Informational document for the aviation community published by the FAA.

Air Eliminator – Filter vessel appurtenance that allows trapped air to escape from the vessel. When the vessel is completely filled with fuel, the air eliminator automatically closes. A check valve prevents air from siphoning into the vessel through the air eliminator.

Airlines for America (A4A) – Airline trade organization in the United States. Formerly Air Transport Association (ATA).

Aircraft Ground Service Guide – Reference guide that includes aircraft servicing details including fuel type and capacity, take-off and landing weights and dimensions, towing information and refueling procedures.

Aircraft Rescue & Fire Fighting (ARFF) – A special category of firefighting that involves the response, hazard mitigation, evacuation and rescue of passengers and crew of an aircraft involved in a ground emergency.

Airworthiness Directive (AD) – Federal Aviation Administration (FAA), and other regulatory authorities, notifications to owners and operators of certified aircraft that a known safety deficiency with a particular model of aircraft, engine, avionics or other system exists and must be corrected.

Ambient Temperature – The air temperature at a specific location.

American National Standards Institute (ANSI) – Standards setting organization that works with U.S. businesses to facilitate voluntary standards that enhance competitiveness.

American Petroleum Institute (API) – Organization that represents all aspects of America's oil & natural gas industry, and develops and publishes voluntary consensus standards.

American Society of Mechanical Engineers (ASME) – Not-for-profit membership organization that enables collaboration and knowledge sharing across all engineering disciplines. ASME codes and standards provide guidelines, procedures and recommended practices for designing, operating, maintaining and testing a wide range of equipment and systems.

Antioxidant Additive – Prevents the formation of oxidation deposits in aircraft engine fuel systems and suppress the formation of soluble gums and insoluble particulates to improve fuel storage stability; see additives.

API Gravity – An arbitrary scale (0–100 degrees API) established by the American Petroleum Institute (API) to express the density of liquid petroleum products. The higher the API gravity, the lighter the compound. The API Gravity of water is 10; see gravity

Appearance – Refers to the visual examination of fuel; appearances are, clear, bright, hazy, and cloudy

Appurtenance – An accessory. Typically used in reference to storage tanks and filter vessels (i.e. DP gauges, water defense systems, automatic tank gauges, water draw piping, air eliminators, pressure relief valves, etc. are appurtenances)

ASTM International (formerly American Society for Testing and Materials) (ASTM) – An international standards organization that develops and publishes international voluntary consensus standards.

Aviation Fuels

Aviation Turbine Fuel (ATF) aka Jet Fuel
- Jet A (freeze point is -40° C) ASTM D1655
- Jet A - 1 (freeze point is -47° C) ASTM D1655
- JP - 5 U.S. Navy fuel (flash point is 140° F)
- JP - 8 U.S. Air Force (flash point is 100° F)

Aviation Gasoline (Avgas)
- 100 LL ASTM D910

Aviation Gasoline – see aviation fuels

B/2HB™ Anti-Icing Additive Test Kit –Test kit sold by Gammon Technical Products used to determine the concentration of Fuel System Icing Inhibitor (FSII) additive in jet fuel; see additives.

Bar – Unit of measure (1 bar = 14.5 PSI)

Bill of Lading (BOL) – Document issued by a carrier to a shipper, acknowledging that goods have been received for transport to a named destination for delivery to a specified consignee.

Biocidal Additive – Kills microorganisms such as bacteria and fungi (i.e., yeasts and molds); See additives.

Biostat – Inhibits growth of microorganisms such as bacteria and fungi (i.e., yeasts and molds).

Bonding – Controlling static electricity hazards by connecting conductive objects together by means of a conductor so that they are at the same electric potential, but not necessarily the same potential as the earth. Not to be confused with grounding: the process of connecting conductive objects to the ground so they are at zero electric potential.

Breathing – The movement of gas (product vapors or air) in and out of the vents of storage tanks.

Bulk Water – see water

Calibration – The graduation of a measuring instrument; the process of determining the accuracy of a measuring instrument.

Cathodic Protection – A method of protecting a buried metal structure (e.g. tanks, piping, etc.) against corrosion by surrounding it with an electrical field. The system utilizes a controlled cell, which shifts the corrosion from the protected structure to a replaceable sacrificial anode.

Certificate of Analysis (COA) – Document issued to confirm that a regulated product meets its product specification. Typically contains the actual results obtained from testing performed as part of quality control of an individual batch of product. For aviation fuels, the applicable product specifications are ASTM D1655 for jet fuel and ASTM D910 for aviation gasoline.

ASTM D1655 Jet Specification Summary

ASTM D910 Avgas Specification Summary

Certificate of Similarity – Documentation assigned to a specific filter vessel to confirm qualification to EI 1581 by similarity.

Check Valve – Mechanical device designed to allow fluid (liquid or gas) to flow in only one direction. Example: the check valve on an air eliminator prevents air from siphoning back into the filter vessel through the air eliminator.

Clay Treater – A vessel that contains special clay canister elements or clay bags, used to remove surfactants (surface active agents) from jet fuel; see filter element

Clear & Bright – Clear is the absence of visible solids, a cloud, a haze, an emulsion, or free water in the product. Bright is the sparkle of clean, dry product in transmitted light.

Coalesce – The function of a coalescer filter element to draw together or combine fine droplets of free water (entrained in fuel) to form large droplets that are heavy enough to drop to the bottom of a filter separator vessel or be repelled by the separator element.

Coalescer Element – The first stage element in a filter/separator vessel that removes solid particles and coalesces free water from jet fuel. It is upstream of the separator element; see filter element

Code of Federal Regulations (CFR) – Codification of the general and permanent rules published in the Federal Register by the executive departments and agencies of the Federal Government.

Color Dye Additive – Required in aviation gasoline; differentiates grades by color; dyes are not allowed in jet fuel; see additives.

Commingling – The mixing of two or more products of different ownership, type, or grade.

Condensation – Natural phenomenon resulting in the change of water from its gaseous form (water vapor in the air) into liquid water commonly occurring when there is a reduction in the temperature of the vapor. In a storage tank, water condensing on the inside of the storage tank walls above the fuel level is a result of the tank surface temperature cooling to the dew point of the air that is in contact with it.

Conductivity – The ability of a substance to conduct electrical current.

Contaminants – Substances which may be present in the fuel that detract from its performance.

Contaminated Product – A product in which one or more grades or types of products have been inadvertently mixed; or a product containing contaminants such as dust, dirt, rust, water or surfactants.

Coordinated Agency for Supplier Evaluation (CASE) – The Air Carrier Section of this organization was designed as a means to allow members to share non-proprietary supplier quality approval data among its members.

Coordinating Research Council (CRC) – Nonprofit organization that directs, through committee action, engineering and environmental studies on the interaction between automotive/other mobility equipment and petroleum products.

Copper Strip Corrosion Test – A qualitative method of determining the degree of corrosivity of a fuel by suspending or placing a strip of polished copper in a sample of fuel and comparing the test strip with a standard.

Corrected Differential Pressure (DP**)** – Observed DP adjusted for the difference between the observed flow rate and the rated capacity of the filter vessel.

Correction Factor – Due to the natural effects of thermal expansion/contraction, petroleum products must be corrected to 60°F for inventory and/or quality control purposes. Petroleum products are temperature corrected by using following API tables:

- Table 5B – Correction of observed API Gravity to API Gravity at 60°F
- Table 6B – Correction of volume at 60°F against API Gravity at 60°F (ASTM D1250)

Corrosion Inhibitor Additive – Prevents free water and oxygen in jet fuel from rusting or corroding uncoated steel that the fuel may contact in the distribution system (i.e., tanks, pipelines). Corrosion inhibitors also improve lubricity; see additives.

Cross Loading – Loading a transport vessel with product that is different than the previous cargos. When cross loading, ensure cargos (current/previous) are compatible. Example: Loading jet fuel after bio-diesel could result in the jet fuel becoming contaminated with Fatty Acid Methyl Ester (FAME) and not meeting the ASTM D1655 Specification. Not to be confused with switch loading.

Transport Cross Loading Chart

Deadman Control – A control device that must be continuously held by the operator to allow fuel to flow. When it is released the fuel flow automatically stops.

Dedicated System – A system of pipelines, filter vessels, tanks and/or trucks used solely to transport and store one grade of aviation fuel only.

Defense Energy Support Center (DESC) – now Defense Logistics Agency (DLA)

Delta P – see differential pressure

Density – Specific weight or mass of a substance per unit volume (e.g. pounds/gallon, grams/ml).

Desiccant Vent Dryer – Device used to dry replacement air entering a storage container by passing it through a desiccant media (typically anhydrous calcium sulfate) to remove moisture/water by absorption. Ensure “indicating” desiccant media (changes color when replacement is needed) is used with Fuel System Icing Inhibitor (FSII) storage.

Differential Pressure (DP) – The difference in pressure between two points, generally at the inlet and outlet of a filter or a filter/separator. Typically measured in pounds per square inch (PSI) and also known as:

- Delta P
- ▲ P
- Pressure Drop
- PSID (pounds per square inch difference)
- Corrected differential pressure

DP is also measured in the following:

- inches of mercury
- kilograms per square centimeter
- kilopascals (kPa)
- bars (1 bar = 14.5 PSI)

Differential Pressure (DP) Gauges – 

Disarming Action – The process by which elements in filtration systems are rendered incapable of performing their designed function.

Dissolved Water – see water

Duckbill Nozzle (J-Spout) – A jet fuel nozzle utilizing a large (wide) spout that will not fit into an aviation gasoline fueling port. The nozzle was designed specifically as a misfueling prevention device.

Effluent – Product flowing on the outlet side of a filtration vessel (see influent)

Electrical Conductivity Additive – Improves fuel conductivity properties to reduce potential fire safety hazards; see additives; aka

- Anti-static Additive
- Conductivity Improver Additive
- Static Dissipator Additive (SDA)
- Stadis® 450

Emulsion – A liquid dispersed in another immiscible liquid. The liquids will not dissolve completely into one another.

Energy Institute (EI) – International chartered professional membership organization providing a forum to facilitate the development and dissemination of energy based knowledge related to best practices, safety, environmental responsibility, efficient supply and use of energy in all forms and applications.

Entrained Water – see water

Environmental Protection Agency (EPA) – Federal agency created to protect human health and the environment by establishing policy and enforcing federal laws.

Evaporation – The conversion of liquid into vapor, typically by means of heat.

Federal Aviation Administration (FAA) – Federal agency created to manage safety and efficiency of national airspace.

- Airworthiness Directives (AD)
- Advisory Circulars (AC)
- Notices to Airmen (NOTAM)
- Special Airworthiness Information Bulletins (SAIB)

Federal Aviation Regulations (FAR) – Rules prescribed by the Federal Aviation Administration (FAA) governing all aviation activities in the United States. FARs are part of Title 14 of the Code of Federal Regulations (CFR). A wide variety of activities are regulated and rules are designed to promote aviation safety and the national security of the United States.

Fatty Acid Methyl Ester (FAME) – The bio-component in biodiesel. FAME is a surface-active material (may stick to vessel walls) that has the potential to contaminate jet fuel if vessels are not properly cleaned.

Filter Element – A device to remove solid particles, water and/or surfactants from fuel. Types of filter elements:

- Clay
- Coalescer
- Filter Monitor (Fuses)
- Filter/Separator (coalescer/separator, filter water separator, two-stage)
- Microfilter (particulate, micronic, pre filter)
- Haypack (dehydrator)
- Separator

Filter Membrane Test (Millipore and Membrane Color Filtration)–Test used to detect particulate contamination in aviation turbine fuel using a field monitor. Two methods available: colorimetric (color rating) for rapid qualitative assessment of particulate contamination or gravimetric for quantitative laboratory measurement of particulate contamination. Addressed under ASTM D2276 (Standard Test Method for Particulate Contaminant in Aviation Fuel by Line Sampling).

Filter/Separator – see filter element

Filtration – Technique used for removing solids from fluids by passing through a medium through which only the fluid can pass.

Fixed Based Operator (FBO) – A commercial business granted the right by the airport sponsor to operate on an airport and provide aeronautical services (e.g. fueling, hangar space, tie-downs and parking, aircraft rental, aircraft maintenance, flight instruction, etc.)

Flash Point – The lowest fuel temperature at which the vapor above the fuel will ignite. ASTM D56 and ASTM D3828

Floating Suction – Pump suction piping that floats on top of the fuel in order to draw the cleanest product from the fuel in a storage tank (typically found in jet fuel).

Free Water – see water

Fuel Recovery System – System to handle recoverable fuel. Recovered fuel is collected in a separator where any water and/or particulate are allowed to separate by gravity prior to returning the fuel to storage. Recovered fuel is typically filtered prior to transfer back into storage.

Fuel System Icing Inhibitor (FSII) – Lowers the freeze point of any free water in aviation fuels; more typically used in jet fuel; see additives; aka

- Anti-icing Additive (AIA)
- Diethylene Glycol Monomethyl Ether (DiEGME)
- Carbitol™
- Prist®
- Fizzy®
- Dice®

Fungible – Interchangeability of like product batches that can be substituted for purposes of shipment or storage.

Fuse – see filter element

Gallon (gal) – A unit that measure volume. 1 U.S. gallon = 3.78541 liters = 231 cubic inches

Gravity

- **API Gravity:** An arbitrary scale (0–100 degrees API) established by the American Petroleum Institute (API) to express the density of liquid petroleum products. The higher the API gravity; the lighter the product. The API Gravity of water is 10.
- **Specific Gravity:** Density of a liquid relative to water. The specific gravity of water is 1.
- **Relative Density:** Density of a liquid relative to a reference substance; like water.

Gauge – A float, site glass or system used to measure the contents of a tank.

Gauging (Strapping) Table – Tank specific measurement tables used to determine the volume of the tank at various increments.

Grounding – The process of connecting conductive objects to the ground so they are at zero electric potential. Not to be confused with bonding: controlling static electricity hazards by connecting conductive objects together by means of a conductor so that they are at the same electric potential, but not necessarily the same potential as the earth.

Haypack – see filter element

Haze – Free water entrained/suspended in fuel that is visible to the naked eye, normally in concentrations greater than 30 parts per million (PPM).

Hydrometer – A graduated instrument for determining the density of liquids. It is usually made of hollow glass and weighted at one end so it will float upright. The depth to which the instrument sinks when immersed in a liquid is determined by the density of the liquid. The lighter the liquid, the lower the instrument sinks. Hydrometers are typically marked to read in degrees of API gravity, specific gravity (relative density), or density; see thermohydrometer.

Hydrophilic – A substance that attracts water (has an affinity for water); opposite of hydrophobic (see below); e.g. FSII additive is hydrophilic

Hydrophobic – A substance that repels or resists water e.g. the outside layer of material used to make separator elements repels water so is hydrophobic; opposite of hydrophilic (see above); e.g. separator filter elements are hydrophobic

Immiscible – Liquids that are mutually insoluble; opposite of miscible. Example: water and oil are immiscible.

Inerting – use of an inert gas to render the atmosphere of a tank or container to be free of oxygen or to reduce the oxygen content to a point at which combustion cannot take place

Influent – Product flowing on the inlet side of a filtration vessel (see effluent)

Injector – Pump like device used to deliver a measured quantity of liquid (typically additives) into a flow or stream of fluid.

Innage – The volume of liquid in a tank measured from the bottom of the tank to the top surface of the liquid e.g. if the tank capacity is 10,000 gallons and it currently contains 6,000 gallons, the innage is 6,000 gallons and the ullage is 4,000 gallons.

Institute of Petroleum (IP) – Now the Energy Institute (EI)

Intrinsically Safe – A protection technique for safe operation of electrical equipment in a flammable atmosphere by limiting the energy available for ignition. By design, a device termed intrinsically safe will not contain any components that produce sparks or can hold enough energy to produce a spark of sufficient energy to cause an ignition.

Jet Fuel Thermal Oxidation Test (JFTOT) – Test results are indicative of fuel performance during gas turbine operation and can be used to assess the level of deposits that form when liquid fuel contacts a heated surface that is at a specified temperature. Covered specifically under ASTM D3241 (Standard Test Method for Thermal Oxidation Stability of Aviation Turbine Fuels) and referenced in ASTM D1655 Standard Specification for Aviation Turbine Fuels).

Joint Inspection Group (JIG) – A group of member companies organized to promote safety, quality control and efficiency at aviation fuel facilities and develop greater global standardization of aviation fuel operating guidelines. Promotes safe and cost effective best practices for aviation equipment and aviation fuel quality control and handling by developing and publishing guidelines for aviation fuel quality control and operating procedures.

J–Spout – see duckbill nozzle

Leak Detection Additive – Assists in detecting leaks in fuel handling systems; see additives.

Leopard Spotting – Noticeable presence of microbial growth on the outer sock of a filter element.

Line Strainer – A screen commonly installed upstream of pump or meter equipment in a fueling system to trap larger sized debris.

Liter (L) – A metric unit that measures volume. 1 liter = 0.264 U.S. gallons

Lubricity Improver Additive – Compensates for the poor lubricity of severely hydrotreated (refining process to remove sulfur compounds) jet fuel; see additives.

Manifold – a chamber having several outlets through which a fuel is distributed or gathered.

Manway – A covered access point in the top or side of a tank through which a person can enter.

Material Safety Data Sheet (MSDS) – A comprehensive informational document prepared by the manufacturer or importer outlining special precautions and controls necessary for handling hazardous chemicals (required under the OSHA Hazard Communication Standard).

Media Migration – Carry–over of fibers and particles from filter or separator media material into the effluent or downstream product flow.

Meniscus – The curve in the upper surface of a standing body of liquid, produced in response to the surface of the container or another object. It can be either convex or concave. A convex meniscus occurs when the molecules have a stronger attraction to each other (cohesion) than to the material of the container (adhesion).

Metal Deactivator Additive (MDA) – Inhibits the catalytic activity of active metal (i.e., copper and zinc) contamination that can degrade thermal stability of jet fuel; see additives.

Microbes (microorganisms) – Bacteria and fungi (yeast and molds) that can enter a fuel system in various ways and can cause a variety of problems.

Microfilter – see filter element

Micron – A unit of linear measure. 1 inch = 0.000039 inches (about 25,400 microns). The diameter of the average human hair is approximately 100 microns.

Microorganisms (microbes) – Bacteria and fungi (yeast and molds) that can enter a fuel system in various ways and can cause a variety of problems.

Micro-separometer Rating (MSEP) – Test protocol found in ASTM D1655 (Standard Specification for Aviation Turbine Fuels) used to detect the presence of low level metal/surfactant contamination that can deteriorate thermal stability.

Miscible – Liquids that are mutually soluble (able to be mixed to form a solution); opposite of immiscible. Example: alcohol and water are miscible.

Misfueling – Delivering the incorrect grade of fuel into an aircraft.

Monitor Element – see filter element

National Air Transportation Association (NATA**) –** National trade association representing the legislative, regulatory and business interests of general aviation service companies.

National Fire Protection Association (NFPA**) –** International nonprofit organization promoting fire prevention and public safety through research, training and education. Develops and publishes codes and standards intended to minimize the possibility and effects of fire.

Notices to Airmen (NOTAM) – Documents issued by aviation authorities to alert aircraft pilots of any hazards en route or at a specific location.

Ohm – A unit that measures electrical resistance; the higher the value, the greater the resistance to electrical flow. Electrical continuity checks are performed on bonding systems to ensure resistance (measured in ohms) to electrical flow along the bonding path is below a designated target.

Outage (ullage**)** – nominal capacity of a tank minus actual contents in the tank e.g. if the tank capacity equals 10,000 gallons and it currently contains 6,000 gallons, the outage (ullage) is 4,000 gallons.

Oxidation – A chemical reaction where two or more materials combine with oxygen to form a new compound.

Particulate Element – see filter element

Particulate Matter – Solid contaminants that may be found in fuel (e.g. dirt, metal shavings, rust, sand, filtration fibers, etc.)

Pilot's Operating Handbook (POH) / Airplane Flight Manual (AFM) – FAA approved documents published by the airframe manufacturer that lists the operating conditions for a particular model of aircraft by serial number.

Plus One Hundred Additive (+100) – Improves the thermal stability of jet fuel by about 100° F. Developed for high-performance military aircraft to help prevent the formation of gums and sediment by keeping potential insoluble compounds in solution see additives.

Precheck System – System designed to prevent fuel spills by verifying the proper operation of the high level shutoff equipment on refueler trucks.

Pressure Drop – see differential pressure

Pressure Relief Valve – Valve designed to open at a specified pressure to exhaust excess pressure built up due to thermal expansion in a non-flow condition.

Pounds per Square Inch (PSI) – A unit that measures pressure.

Qualitative – Subjective information dealing with appearance and descriptions; data that can be observed but not measured (i.e., color, odor).

Quantitative – Objective information that is number-based; data that can be measured (i.e., dimensions, weight, etc.).

Recoverable Fuel (aka reclaim fuel) – Fuel removed from a fueling system (non-aircraft) for purposes of quality control checks or maintenance, and determined to be acceptable for return to storage.

Refractometer – Device used to determine the concentration of Diethylene Glycol Monomethyl Ether (DiEGME) (see additives) in jet fuel by measuring the refractive index of a water extract. Refer to the latest edition of ASTM D5006 for the test method and a list of currently approved refractometers.
see Section 5.4 Fuel Quality Testing - FSII Test

Relative Density (specific gravity) – The density of a substance relative to a reference substance like water; see gravity.

Reid Vapor Pressure (RVP) – Named after the creator of the test (Reid), this is the amount of pressure in a sealed container as fuel temperature is increased. Therefore, high RVP product has more of a tendency to vaporize than low RVP product.

Repeatability – The allowable difference between two test results; see reproducibility.

– same sample
– same operator conducts the tests
– same equipment used to conduct the tests

Reproducibility – The allowable difference between two test results; see repeatability.

– same sample
– different operators conducting the tests
– different equipment used to conduct the tests

Sediment – Accumulation of particulate material that settles out of a liquid by the force of gravity acting on the material itself. Example: Rust/scale from tanks/pipes and airborne solids accumulating in the bottom of a storage tank.

Separator Element – see filter element

Settling Time – The time allowed for water or dirt entrained in the fuel to drop to the bottom of a storage tank. Recommended settling time:

- Jet Fuel – one hour per foot of product height
- Aviation Gasoline – fifteen minutes per foot of product height

Shared Inspection Group (SIG) – Group of companies organized to allow members to share inspections of pre-airfield terminals based on API 1595 (Design, Construction, Operation, Maintenance and Inspection of Aviation Pre-Airfield Storage Terminals - Recommended Practice).

Shelf Life – Recommended amount of time that fuel can be stored and continue to meet applicable ASTM specification.

Tech Topic – Shelf Life of Aviation Fuels

Similarity Data Sheet – EI 1582 documentation necessary to qualify jet fuel filter/separators to EI 1581 by similarity, rather than laboratory testing. Similarity sheets show that the operating parameters of the candidate vessel are sufficiently similar to a system already EI 1581 qualified.

Slug Valve – A valve that, when signaled by a float or probe, will shut down the flow of fuel when excess water is detected in a filter vessel sump.

Soluble – Capable of dissolving or passing into solution. Examples: Sugar is soluble in water, alcohol is soluble in water.

Spark Arrester – Device that prevents the emission of flammable debris from combustion sources such as internal combustion engines. Requirements for flame and spark arresting engine exhaust systems are addressed in NFPA 407.

Special Airworthiness Information Bulletin (SAIB) – Federal Aviation Administration (FAA) informational tool that alerts, educates, and makes recommendations to the aviation community. SAIBs contain non-regulatory information and guidance that does not meet the criteria for a FAA Airworthiness Directive (AD).

Specific Gravity – see gravity

Spill Prevention, Control and Countermeasure (SPCC) – Requirements for oil spill prevention, preparedness and response to prevent oil discharges into navigable waters and adjoining shorelines. Compliance enforcement is managed by the Environmental Protection Agency (EPA).

Static Electricity – Phenomenon created by the buildup of electrostatic charge on the surface of an object caused by the movement of electrons between two objects when they are in contact. This movement of electrons results in a charge imbalance when the materials are separated. Aviation fuels are poor conductors of electricity which promotes the accumulation of electrostatic charge on the fuel as it flows through pumps, pipes, filters and hoses.

Static Inventory (Static Stock) – Inventory to which no product has been added.

Sump (noun) – A low point in a system designed for the collection and removal of water and particulate contaminants.

Sump (verb) – Procedure of removing fuel from the low points of a fuel system (e.g., storage tank, filter vessel, etc.) to detect and remove any visible water and/or particulate contaminants.

Sump Fuel – Fuel removed from sumps (e.g. storage tank, filter vessel, etc.) during routine quality control checks performed to detect and remove water and/or particulate contaminants. Sump fuel may be eligible for reclaim/recovery.

Supplemental Type Certificate (STC) – A type certificate issued by the FAA when an applicant has received approval to modify an aircraft from its original design. The STC, which incorporates by reference the related type certificate, approves the modifications and also addresses how the modification affects the original design.

Super Absorbent Polymer (SAP) – A type of media used in water absorbing "monitor" filter elements to remove free water from aviation fuel. The absorbed water is chemically locked into the media.

Surface Active Agents (surfactants) – Polar compounds that make it difficult for free water to separate from fuel and can disarm coalescer elements.

Surfactants (surface active agents) – Polar compounds that make it difficult for free water to separate from fuel and can disarm coalescer elements.

Surge Tank – A small tank used to collect fuel expelled from devices such as air eliminators and pressure relief valves.

Suspended Water – see water

Suspension – Small particulates or droplets of a liquid (typically water in aviation fuels) finely dispersed throughout a less dense liquid or gas in which they are not soluble; filterable but not easily settled; water suspended in aviation fuels give the fuel a hazy or cloudy appearance.

Switch Loading – Loading of low vapor pressure products into a transport vessel that previously contained a high vapor pressure product, such as loading kerosene or diesel fuel into a vessel previously containing gasoline. This creates an environment that increases the risk of static discharge and flash fire during the loading process. Not to confused with cross loading.

Temperature – a physical property of matter that quantitatively expresses the qualitative notion of hot and cold; see also ambient temperature

Tetraethyl Lead (TEL) – Required in aviation gasoline; improves the antiknock characteristics of the fuel by preventing uncontrolled combustion; see additives.

Thermal Stability – Performance characteristic of jet fuel related to the ability to resist oxidation and polymerization that impact the amount of deposits formed in the engine fuel system when the fuel is heated.

Thermohydrometer – Device that includes both a hydrometer scale for measuring fuel density and a thermometer scale to measure temperature; see hydrometer.

Thief (Sump) Pump – A small pump having a suction line that extends to the low point of a tank, used to detect and remove any accumulated sediment and/or water.

Turbine Fuel – see aviation fuels

Ullage (outage**)** – nominal capacity of a tank minus actual contents in the tank e.g. if the tank capacity equals 10,000 gallons and it currently contains 6,000 gallons, the ullage is 4,000 gallons and the innage is 6,000 gallons.

Undissolved Water – see water

Underwriters Laboratories (UL) – Global independent standards development organization, testing lab and certification body utilizing safety science and hazard-based safety engineering to enhance life safety and facilitate global commerce. The UL Mark on a product means that UL has tested and evaluated representative samples of that product and determined that they meet UL requirements.

Viscosity – A measure of the resistance of a liquid to flow (related to the pumpability over a temperature range). The viscosity of petroleum products is commonly expressed in terms of the time required for a specific volume of the liquid to flow through an orifice of a specific size.

Vapor Lock – Occurs when liquid fuel changes to a gas state (vaporizes) while in the fuel delivery system. This disrupts fuel supply to the carburetor or fuel injection system resulting in loss of power or stalling, and difficulty restarting the engine.

Vent – An opening in a vessel (tank, container or pipe) that allows the flow of air/vapor in and out, due to changes in pressure (related to changes in temperature, volume, etc.). The general purpose of venting is to prevent over pressurization or collapse of the vessel.

Waste Fuel – Fuel that can no longer be used for its intended purpose due to contamination or specification issues.

Water Finding Paste – Paste that changes color upon contact with water (typically applied to the end of a stick to determine the amount of water in the bottom of a tank).

Water

- **Dissolved Water:** Water in solution in the fuel. Typically, aviation fuel contains some trace levels of dissolved water which does not create any issues in aviation fuel handling operations. Dissolved water is part of the fuel and therefore cannot be removed by conventional aviation fuel filtration.

- **Free Water** (Undissolved)**:** Water in fuel other than dissolved water. Free water may be introduced into fuel when dissolved water levels exceed the solubility limits of the fuel and free water precipitates out of the fuel (e.g. when the cools). Free water may also be introduced by water contamination from an external source (e.g. transport deliveries, leaking dome hatch).

    - **Entrained/Suspended Water** – Free water finely dispersed in the fuel. It may not be visible in concentrations less than 30 parts per million (PPM) and can make the fuel appear hazy/milky at higher concentrations. Filtration is required to remove free water from fuel.

    - **Bulk water (Water Slug)** – Free water in the form of droplets or a layer of water at the bottom of a fuel container (e.g. white bucket, filter sump, storage tank bottom) and can be removed by sumping.

Water in Solution – see water

Water Slug – see water

Acronyms & Abbreviations

ANSI	American National Standards Institute
API	American Petroleum Institute
ARFF	Aircraft Rescue Fire Fighting
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
A4A	Airlines for America (formerly Air Transport Association)
ATF	Aviation Turbine Fuel
BOL	Bill of Lading
BTU	British Thermal Unit
CASE	Coordinating Agency for Supplier Evaluation
CFR	Code of Federal Regulations (FAA)
COA	Certificate of Analysis
CRC	Coordinating Research Council
CU	Conductivity Unit
DEF STAN	Defense Standard
DESC	Defense Energy Support Center (now DLA: Defense Logistics Agency)
DHS	Department of Homeland Security
DiEGME	Diethylene Glycol Monomethyl Ether
DLA	Defense Logistics Agency (formerly Defense Energy Support Center {DESC})
DOT	U.S. Department of Transportation
EI	Energy Institute
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulations
FSII	Fuel System Icing Inhibitor
GPM	Gallons Per Minute
ISO	International Organization for Standardization

IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IP	Institute of Petroleum; now the Energy Institute (EI)
JFTOT	Jet Fuel Thermal Oxidation Test
JIG	Joint Inspection Group
kPa	Kilo Pascal
MJ	Mega Joules
MOD	Ministry of Defence
MSDS	Material Safety Data Sheet
MSEP	Micro Separometer (formerly known as WSIM)
NATA	National Air Transportation Association
NIST	National Institute of Standards and Technology
NFPA	National Fire Protection Association
NTSB	National Transportation Safety Board
OSHA	Occupational Safety & Health Administration
PFA56MB	Phillips Fuel Additive (Phillips 66 brand name for FSII or DiEGME)
PPM	Parts per Million
PSI	Pounds per Square Inch
PSID	Pounds per Square Inch Difference
PSIG	Pounds per Square Inch Gauge
pS/m	pico Siemens per meter
RVP	Reid Vapor Pressure
SAE	Society of Automotive Engineers International
SAIB	Special Airworthiness Information Bulletin (FAA)
SPCC	Spill Prevention, Control and Countermeasure (EPA)
SDA	Static Dissipator Additive
STC	Supplemental Type Certificate
TEL	Tetraethyl Lead

UL	Underwriters Laboratories