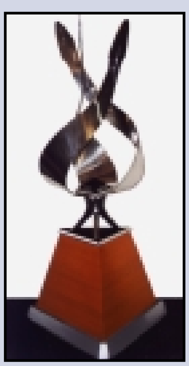
TRIAVIATHON TROPHY

CHALLENGE TROPHY



CAFE FOUNDATION

HOMEBUILDER ALERT

Sponsored and Funded by the Experimental Aircraft Association and the Federal Aviation Administration

Fuel Handling Safety

BY BRIEN A. SEELEY AND THE CAFE BOARD

Brien Seeley

The CAFE Foundation flight testing program involves routinely obtaining an aircraft's empty weight by draining all of the fuel from the aircraft being evaluated. The aircraft is then re-fueled from five-gallon containers using the previously off-loaded fuel. The risk of a spark of static electricity igniting the fuel has prompted us to develop and adopt correct safety procedures for the draining or re-fueling process. This topic is also pertinent to the increasing use of autogas in aircraft. Transporting, storing and dispensing autogas in portable containers must be done with strict safety precautions.

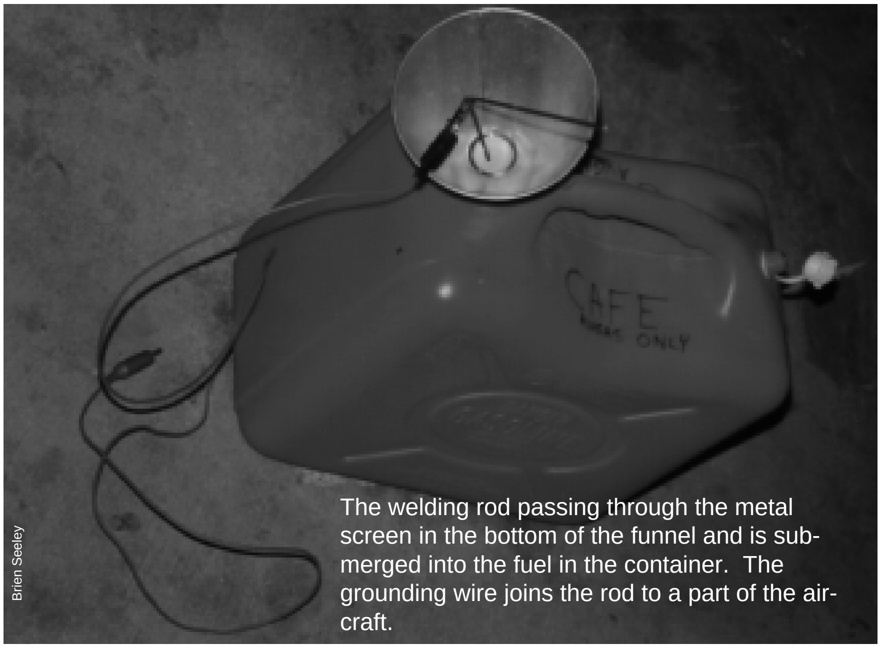
STATIC SPARK

The friction of air flowing over the skin of an aircraft in flight can produce a static charge buildup on the aircraft. This charge can build up on a metal, plastic, wood or fabric airplane. For non-metal aircraft, it is difficult to completely and quickly dissipate this electrical charge. A composite aircraft is probably the variety most prone to develop and sustain a static charge due to the low conductivity of fiberglass structure. The recent proliferation of composite aircraft makes the issue of static charge dissipation a more frequent concern.

Tires are good enough conductors to allow road vehicle's electrical charge to escape to ground, especially if the tires are dirty or oily. However, an aircraft may not dissipate its charge to ground for several hours. Cement or dirt are better conductors of electricity than asphalt and, therefore, better grounding surfaces.

In flight, a static charge can spontaneously discharge to the atmosphere when it reaches a high enough voltage. Static dissipators on wing trailing edges are used to control this effect on aircraft, and allow a charge buildup to discharge to the atmosphere at a much lower voltage. This avoids radio interference and makes the aircraft less likely to attract lightning.

Static charge tends to focus on an object's corners, edges and sharply pointed locations; hence static dissipators are often fine-tipped brushes made of multiple strands of wire and are attached to the wing trail-



The welding rod passing through the metal screen in the bottom of the funnel and is submerged into the fuel in the container. The grounding wire joins the rod to a part of the aircraft.

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ing edge near the wingtip. The same principle is used in the design of spark plug electrodes, arc welding, lightning rods, and the sharply pointed electrodes used in college physics demonstrations.

A static charge can form on a person's clothes if that person happens to rub against a non-metal aircraft or against a plastic fuel container while wearing a rayon or wool sweater or sweat pants, especially on dry winter days. Even the fuel itself, although it is a very poor conductor, can develop a static charge. . .

STATIC CHARGE IN FUEL

One of the best sources of information on this topic can be found at the Chevron USA web site at www.chevron.com. Chevron's public information release on static spark states that . . . *"Gasoline has a low electrical conductivity--it does not conduct electricity very well. As a result, a charge of static electricity builds up on gasoline as it flows through a pipe or hose and this charge takes several seconds to several minutes to dissipate after the gasoline has reached a tank or container. If this charge discharges as a spark from a tank or container to the grounded metal nozzle of the gasoline dispenser hose, it may ignite the gasoline. Ignition requires that the spark occur near the tank opening where the gasoline vapor is in the flammable range. A spark discharge directly from the surface of the gasoline to the grounded nozzle also is possible. Normally, this will not result in ignition because the concentration of gasoline vapor near the liquid is above the flammable limit.*

Gasoline vapor can be ignited only when its concentration in air is between 1.4 and 7.6 percent by volume. At lower concentrations there is too little vapor for ignition and at higher concentrations there is too little air (oxygen) for ignition."

The static charges in the fuel in a 5 gallon container will repel one another and will tend to distribute to the walls of a fuel container. Wiping down a plastic vessel with a saline-soaked rag while the vessel sits on a concrete floor will largely dissipate the charge of the fuel and the vessel. Using a saline soaked rag to wipe off the wing of a composite aircraft would also dissipate the charge on the wing skin. However, one must be careful not to expose the aileron hinges and landing gear to the corrosive effect of the saline runoff.

MEASURING STATIC CHARGE

Detecting a static charge with a VoltOhmmeter is essentially impossible, since the moment it is touched, the charge dissipates and vanishes in the VOM circuit. Special static field testors are necessary to detect a static charge.

We used a static testor and found that:

DRAINING FUEL

All fuel draining should be performed outdoors using approved fuel containers. When draining fuel from an aircraft into a plastic or metal fuel container, the container should first be placed on the ground or concrete floor a safe distance from any ignition source. The distance that is "safe" depends on the conditions, but placing the container about five feet from an ignition source usually should be sufficient. Placing a container on the ground makes it easier for electrical charge to escape.

Gasoline vapor can flow along at ground level for some distance when not dispersed by air currents. If ignited, the vapor becomes a fuse that brings the flame back to the liquid gasoline source.

The location chosen for placing a portable container on the ground for filling should be out of the path of other vehicles, and other people should be kept away while the container is being filled. Make sure that all smoking materials (cigarettes, pipes, etc.) are extinguished. Place a fire extinguisher nearby.

Shut off all engines when handling fuel. This applies to generators, motorscooters or any other engine in the vicinity of the fueling handling operation. Be sure there are no other ignition sources nearby such as pilot lights, air compressors, etc.

Engines that have just been turned off still have hot surfaces (exhaust manifold and catalytic convertor) that could ignite gasoline vapor. Wait at least 2 minutes after shutting down any engine to begin the draining process.

Next, any static charge must be carefully dissipated by grounding. Grounding must be provided for the static charge of the aircraft structure, as well as that of the fuel in the aircraft, on the person doing the de-fueling, and on the receiving container. All connections to accomplish this grounding must be made in the proper sequence. In so far as possible, carefully avoid making a grounding connection when gasoline fumes are present by keeping filler caps and lids closed on all fuel containing vessels.

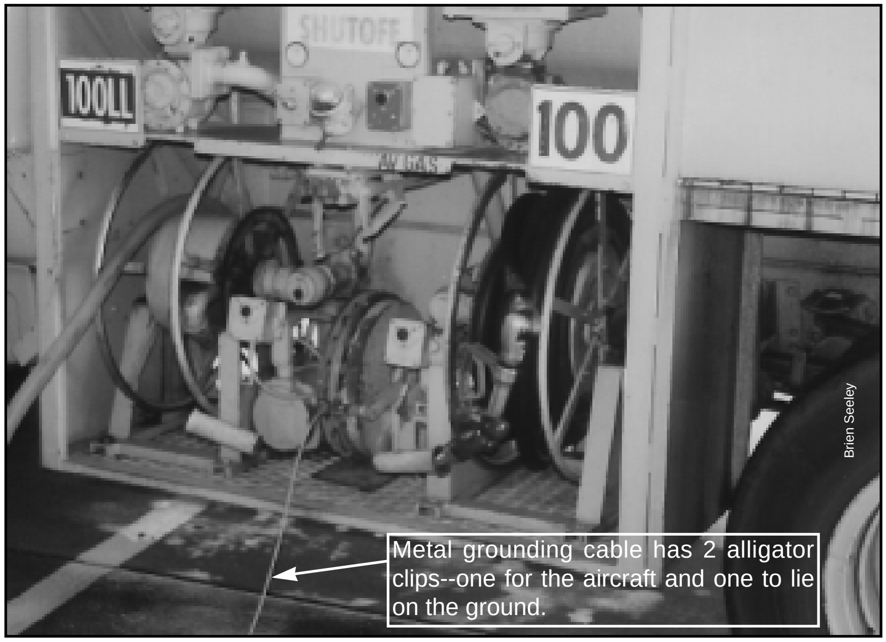
Ideally, the person draining the fuel should wear all-cotton clothing and preferably wear grounding strap shoe covers. That person can dissipate some of the static charge of the aircraft by touching the wing or other part of the aircraft with a bare hand, especially a sweaty hand.

To facilitate draining fuel from an aircraft, obtain a 1/8" or 1/4" NP brass drain fitting which has a 1/4 or 5/16" hose bib outlet. The hose bib outlet should be capped temporarily with a flexible press-on neoprene cap, available at many auto supply stores. An aircraft's fuel quickdrain fitting can be replaced with this capped brass drain fitting Be sure to wear short sleeve clothing when doing this, since there is a tendency for fuel to run down the forearm when changing the fitting.

A 1/4" or 5/16" I.D. hose suitable for use with gasoline and a separate wire running full length alongside the hose can create the grounding path. The far end of the hose and wire are first placed into the receiving vessel which has been placed on the ground or concrete in a safe outdoor location. The hose can then be attached to the hose bib. If it is a metal braided hose, the braid can be alligator clipped to the metal fitting and the separate grounding wire is unnecessary. If the hose does not have a metal braid, the wire should be alligator clipped to the metal fitting after the other end of the wire has first been submerged into the bottom of the receiving vessel. It is sometimes easiest to first place a clean welding rod into the receiving vessel and then alligator clip the wire to that rod prior to attaching the wire to the metal drain fitting. This helps assure that the grounding conductor is submerged into the bottom of the receiving vessel.

Another way to do this is to use a 1" x 3" x .125" clean aluminum plate as an anchor at the bottom of the receiving fuel container with the plate clamped onto a long wire. The wire should exit the mouth of the fuel container as a bare wire passing through a metal funnel and have its other end alligator clipped onto the aircraft's metal fuel quickdrain fitting or to the fuel filler or the aircraft's aluminum fuel line. The attaching of the alligator clip should be done prior to removing the fuel filler cap and thus prior to releasing any fuel vapors.

The RANS S-7C recently tested here had its fuel drained by a novel and safe method devised by CAFE Foundation Board Member, Otis Holt. He placed a carefully selected length of welding rod into the mouth of a 5 gallon plastic container and positioned it under the aircraft's belly quickdrain so that the rod actuated the quickdrain and served as a 'wick' for the fuel to enter the container through a metal funnel. The rod could be grounded by a wire, one end of which was alligator clipped to the welding rod and the other end to both the aircraft's metal structure and to the ground. The welding rod extended all the way down to the bottom of the container, constantly immersed in fuel as the container filled. The container sat on a concrete surface under the aircraft.



Metal grounding cable has 2 alligator clips--one for the aircraft and one to lie on the ground.

FUEL DISPENSERS

When filling an aircraft's wing tank, the fumes of the fuel, being heavier than air, will tend to flow over the wing surfaces, hugging them on their way downward toward the ground level. The same precautions against ignition sources as with fuel draining should be used with fuel dispensing. The dispensing fuel truck must have a fire extinguisher.

Avgas fuel trucks are required to have their fuel delivery nozzles grounded to the fuel tank. In addition, they must have a grounding cable. One end of this cable attaches to the tank on the truck. The other end is mounted on a retracting reel and splits into 2 separate cables. Each of the separate cables has an alligator clip on its end Standard procedure is to ground the tank to the aircraft by attaching one alligator clip to a metal part of the landing gear and lying the other clip on the concrete, asphalt or on the ground nearby. This should be done <u>prior</u> to approaching the aircraft with the filler nozzle so that the nozzle will have essentially the same electrical charge as the aircraft.

In composite aircraft or aircraft equipped with fiberglass fuel tank(s), the fuel tank filler neck(s) may not be grounded. Homebuilders of such aircraft should make a special point of attaching an internal grounding wire from the tank filler neck to the aircraft's metal ground bus, and this, in turn, should be grounded to the landing gear.

Since the integrity of this grounding scheme cannot be assured in every case, caution should be used when approaching the filler neck with the nozzle. The electrical potential for spark may still be present. Before removing the filler cap, the nozzle of the dispensor should first be touched to the metal filler neck of the aircraft to dissipate any incipient spark while no fumes are present at the filler neck.

The nozzle should be kept in continuous contact with the filler neck throughout the filling process, especially at the moment when the fuel flow is shutoff. Keeping the dispenser nozzle in contact with the container at the inlet or with the fuel tank fill tube creates another path by which electrical charge can escape. If the nozzle is not touching the filler neck at the moment of fuel shutoff, when the electrical continuity between the stream of fuel and the receiving tank is suddenly interrupted, a spark could jump the resulting air gap .

A second factor in avoiding static spark is to fuel more slowly. The slower gasoline flows, the less static electricity is generated. In using a portable container to fuel gasoline-powered equipment, people usually pour fuel more slowly than it is delivered by a dispenser.

PORTABLE CONTAINERS

Chevron issues this advice regarding portable containers:

Portable containers can be ranked in their safety as follows:

Most Hazardous: Ungrounded metal container.

Less Hazardous Non-conducting container (e.g., plastic container).

Least Hazardous Grounded metal container.

Only use an approved container. It is unlawful and dangerous to dispense gasoline into unapproved or improperly labeled containers.

To be approved, a container must be predominantly red in color and must be able to hold gasoline securely without risk of leaking or breaking. Glass containers are not approved for transporting or storing gasoline. The container also must bear a warning label about the dangers of gasoline. Approved containers made of metal or plastic are available at hardware and automotive supply stores.

A container with acceptable strength and durability can be made from either metal or plastic when properly designed and manufactured. Metal containers, when grounded, provide the greatest protection against fires caused by static electricity. Plastic containers will not rust or corrode when gasoline is stored in them for a long time.

Metal containers should be free of corrosion. Plastic containers should be free of stress cracks.

Never lock the nozzle trigger in the open position. Because portable containers are much smaller than vehicle fuel tanks, they fill a lot faster. To prevent over-filling or a spill, the customer needs to control fuel flow, which is why Chevron recommends against locking the nozzle trigger-valve open while filling a portable container.

In many areas, gasoline nozzles are equipped with an accordion-like sleeve to reduce emissions of gasoline vapor during fueling. The sleeve helps return *the vapor in the vehicle's tank to the service station's tank. The sleeve must be compressed to activate the nozzle. When fueling a vehicle, this happens naturally when the nozzle is inserted into the filler spout. The same procedure isn't practical with a container because inserting the nozzle into the inlet far enough to compress the sleeve will activate the nozzle's shut-off mechanism when the container is only partially full. Chevron recommends that a customer compress the sleeve with one hand while controlling the nozzle valve with the other. This procedure allows the customer to see that the nozzle remains in contact with the container. It also allows the customer to monitor the rising fuel level and to stop at the appropriate time.*

Do not fill the container more than 95% full. The remaining air space allows room for the gasoline to expand if it warms up later. Otherwise, expansion could force liquid gasoline out of the container or distort the container.

The above instructions also apply to rack-mounted, five-gallon, military-type fuel containers, which should be removed from the vehicle and placed on the ground for filling; and to portable containers used as fuel reservoirs for outboard marine engines, which should be removed from the boat and placed on the ground or on the wharf for filling.

TRANSPORTATION

Before putting a container of gasoline in the trunk of a vehicle or the bed of a pickup or truck, tighten the cap of the container and the cap of the air vent, if there is one. Wipe the outside of the container to remove any liquid gasoline or gasoline residue.

Secure the container in the trunk or pickup so turns or road vibrations won't cause it to slide around or tip over. Do not leave a container of gasoline in direct sun, or in the trunk of a car that is in direct sun. Heating the gasoline will build up pressure in the container.

FUEL STORAGE

The Uniform Fire Code only approves one- and two-gallon metal or plastic containers for the <u>indoor storage</u> of Class I-A flammable liquids, the class to which gasoline belongs. Furthermore, the Code states that the quantity of gasoline stored in approved containers in private garages or other approved locations shall only be the amount necessary for maintenance purposes and operation of equipment and <u>shall not exceed 10 gallons,</u> unless it is stored in a storage cabinet designed for flammable liquids, in which case the limit is 30 gallons.

Even normal storage situations should have the following elements, but ,in long-term storage they are essential to success. These elements are:

**Keep the fuel cool, but not too cold.*

**Keep the fuel free of water.*

**Keep the fuel away from harmful metals.*

The best way to keep the fuel cool but not too cold is to put the tank underground. If buried with at least 3 ft. of earth over the tank top, it is rare that the fuel temperature will exceed 70°F or drop below 50°F, except in arctic regions.

Above ground tanks and lines must be coated with reflective paint to minimize heat absorption and must be in a location shielded from direct sun. Some means to provide heat (steam tracing, electrical heating tape) will be needed for exposed equipment in really cold weather where burners or diesel engines are served.

There is only one sure way to keep a fuel system dry: check for the presence of water on a regular basis, and remove it when found. The check for water should be a direct visual observation of a sample from the lowest point in the tank.

The metals to avoid are copper and its alloys, such as monel; and zinc, usually found in galvanized coatings on steel tanks and pipes. Copper greatly speeds gum formation. Zinc, in the presence of water, can form a zinc hydroxide gel which rapidly plugs filters. Zinc can also react with tiny amounts of weak organic acids in diesel/heating fuels to form compounds which foul injectors and burners.

The useful life of fuel is a function of proper fuel selection and of storage conditions. For maximum trouble-free life, both these items must be considered jointly, as neither can carry the burden of service dependability without regard to the other.

The following may be used as a guide to a relative stability:

Estimated Useful Life inYears Chevron Gasolines:

Aviation Gasolines	*2 years*
Automotive Gasolines	*1-2 years*
Chevron Jet Fuels	*3-4 years*

Chevron's Material Safety Data Sheet (MSDS) for gasoline provides this overview of the product's hazards:

- *Extremely flammable.*
- *Harmful or fatal if swallowed--can enter lungs and cause damage.*
- *Vapor harmful.*
- *May cause eye and skin irritation.*
- *Long-term exposure to vapor has caused cancer in laboratory animals.*
- *Keep out of reach of children.*

The MSDS provides detailed information on the hazards associated with gasoline and the appropriate responses. A customer may obtain an MSDS for Chevron gasoline by calling (800) 689-3998.

FOOTNOTES

1 American Society of Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428; (610) 832-9585.

2 Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL 60062; (847) 272-8800.

3 ASTM F 839 - Standard Specification for Cautionary Labeling of Portable Gasoline Containers for Consumer Use.

4 Petroleum Equipment Institute, P.O. Box 2380, Tulsa, Oklahoma 74101; (918) 494-9696.

ACKNOWLEDGEMENTS

This work was supported in part by FAA Research Grant Number 95-G-037. The CAFE Foundation gratefully acknowledges the assistance of Chevron USA, Ethyl Corporation, and Daryl Lenz at EAA Headquarters.

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