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VECTOR

Pointing to Safer Aviation

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Static in the Operation

CAA Field Safety Adviser Owen Walker has contributed the following article. Owen is a qualified aircraft engineer and brings his knowledge, and over 30 years of practical experience, together in this article to explain how static electricity can affect us in everyday aircraft refuelling operations. He places particular emphasis on the formation of external static charges in flight and the use of equipment within the refuelling environment. This article complements "Static in the Fuel" in our previous issue.

External Static Charges

Static electricity is not generated by friction, but instead by the movement of a non-conducting material (such as dry air) across a surface, and in contact with a conducting material, thus creating a potential difference (PD). External static charge build-up occurs in an aircraft (and its fuel) as it moves through the air. The movement of an aircraft through the air can create a large PD relative to the earth, especially with the increasing use of composites in today's aircraft construction. The phenomenon called 'St Elmo's fire' is a marvellous example of large amounts of static build-up, and it can result in a powerful static discharge across the aircraft windscreen when in flight.

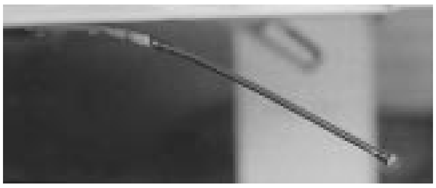
Static dischargers fitted to the trailing edge surfaces of some aircraft help to reduce static potential.

Separate aircraft components can create PDs in themselves, meaning that bonding wires have to be used throughout the aircraft to maintain the components at the same potential. Static generated by the aircraft is dissipated into the atmosphere through the fitting of static discharge lines, or simply from an extremity of the aircraft.

"It is therefore easy to become complacent about the need to static bond an aircraft."

In theory, there should be a zero PD between the aircraft and the ground upon landing. Trailing static wires, and tyres impregnated with conductive material, should dissipate any static charge, thus bringing the PD between the aircraft and earth back to zero. In practice, this is not necessarily the case.

Ground and atmospheric conditions affect



the rate of static dissipation – dry air will inhibit the process. Snow is also an insulator, as are wooden heli-pads, and the scrub on which helicopters sometimes land. Very dry concrete (sometimes poured with plastic under it) also provides insulation. Even on a dry windy day, with the aircraft stationary, a static charge may build if the aircraft is insulated from earth.

When it comes to fuelling, many factors can create a PD between an aircraft and the fuel being transferred to it. Aircraft electrical systems use the aircraft frame as part of the electrical circuit. This means that there is a potential for spark generation to occur during refuelling if the aircraft electrical systems are left on. It is best to shut all electrical systems down before commencing refuelling operations. Note that ground-fuelling equipment may have a different polarity to the aircraft – especially if it is electrically operated.

Fuel and Air Mixtures

Commonly used terms when referring to fuels are flashpoint and volatility.

Flashpoint is a measure of the fuel temperature relative to the amount of vapour that needs to be given off to ignite it. This is not a precise measure, however, as there are too many variables. The temperature range at which fuel vapour concentrations can be explosive (at ground level in an equilibrium state) are approximately: Avgas –10 to –40 degrees Celsius; kerosenes (Avtur, Jet A-1) +38 to +80 degrees Celsius; and wide-cut fuels (JP-4) –20 to +10 degrees Celsius.

Volatility is a measure of a fuel's ability to evaporate under varying conditions of

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temperature and pressure. Hydrocarbon fuels will not ignite as a liquid; rather, they must be in a vaporised form and combine with oxygen (present in the surrounding air) to create a flammable mixture.

Fuel pump hose diameter, nozzle diameter, and fuel transfer speed, all affect the rate at which static is generated while refuelling.

There is a relationship between flashpoint and the volatility of aviation fuels. The temperature that gives about 10 percent distillation of a fuel is the point where just enough vapour is given off to create a flammable mixture.

> *"... often overlooked... fuel drums... insulated from the ground... sitting on the back of a truck, resting on scrub..."*

Temperature is not the only method of creating fuel vapour. Mists or atomisation, generated by sloshing and forcing fuel through nozzles (at any temperature), are equally ignitable. This has proven to be the overriding factor when fuelling.

Fuel vapours, enclosed in a tank, will ignite with an air-to-fuel ratio of between 75:1 by volume at the lean limit and 13:1 at the rich limit. Beyond these limits the fuel vapours will not ignite. Note that the potentially most lethal air-to-fuel ratio occurs at approximately 34:1 by volume, because this is the ratio where the minimum amount of energy is required for ignition. Air-to-fuel ratios within these limits **can easily occur** through the misting or sloshing of fuel as it is forced through a nozzle into the tank. The **air-to-fuel ratio** is one of the most important variables in the prevention of refuelling fires or explosions.

Hot Refuelling

Hot refuelling is a term for a refuelling operation that takes place with the engine burning and the blades turning. This operation is mainly confined to helicopters, but it can also apply to some fixed-wing aircraft. In either case, the machine is made of conducting and non-conducting materials, and a static charge is building up while everything is rotating. This situation creates a very efficient self-generating 'charging machine' for want of a better term. The dissipation of the resulting charges that build up is to earth – if that is possible. If the aircraft is insulated from earth, or there is a resistance, the rate of dissipation through the atmosphere (or the earth) will be less than the rate at which the charge is building up. The static charge will then build up to such a level that it will overcome this resistance threshold and a discharge will occur – through the point of least resistance. If the easiest path is the hand-held fuel nozzle, then the static charge will take it.

Myths About Static Electricity

- Myth: Avtur (Jet A-1) and Avgas are safer than JP-4 (wide-cut fuels), therefore there is less of a fire risk through static discharge.

New Zealand does not use wide-cut fuels for general aviation. Avgas is generally more volatile at lower temperatures than both JP-4 and Jet A-1 in standard equilibrium conditions, and therefore may have vapour concentrations too high to actually explode. On the other hand, Jet A-1 is less volatile than Avgas, but it can generate an explosive mixture within the normal operating temperature range found at many aerodromes around the country. Jet A-1 can therefore be more dangerous in this respect than Avgas at normal environmental temperatures.

- Myth: New Zealand rarely gets hot enough to create an explosive fuel vapour mixture.

Research has shown that during refuelling operations, fuel vapours and/or mists are present at temperatures far below the standard equilibrium temperature required for vapour to be generated in hydrocarbon fuels. Flammable mixtures are present in all fuels within New Zealand's operating temperature range.

- Myth: Jet fuel is safe because it is not as volatile as Avgas or wide-cut fuels.

Fuel vapours and mists only need to have the correct air-to-fuel ratio to ignite. In practice this can be achieved at any operating temperature, making jet fuel (Jet A-1) just as dangerous.

Precautions

An area associated with 'in-the-field refuelling' that is often overlooked is the location of fuel drums. They can be insulated from the ground, and the aircraft, if they are sitting on the back of a truck, resting on scrub – or on any other insulating platform for that matter. Bonding the aircraft and the fuelling equipment **to ground is necessary** to ensure a conductive path is always available. This dissipates the static charge being continuously created and maintains the same PD between the aircraft, the fuelling equipment, and the earth.

Field operations often utilise portable pumping equipment. This equipment usually uses paper (WIX) filter elements, and sometimes Go-No-Go water separator filters, attached to a 12- or 24-volt pump with a short small-diameter hose, and nozzle. The rapid transfer of the fuel over these filters charges the fuel molecules. Small-diameter hoses create fast movement, and a misty mixture upon entering the fuel tank. Short hoses, and possibly the material that the hose is made of, do not allow time for the fuel to 'relax', and any internal static charge may dissipate by means of a spark inside the tank. **Bonding will not prevent this situation**. To minimise the possibility of an internal static charge, the speed of the fuel transfer and the length and type of hose material **must be taken into account**.

Ensure that the static line clip makes metal-to-metal contact with the aircraft structure – this may require a slight scraping motion (on a non-painted surface such as an exhaust pipe or undercarriage strut) to confirm that a contact has been made. Note that many aircraft have grounding plug receptacles at or near the fuelling caps, and it is worth utilising these.

External static charges are forever present, and their intensity at any given time cannot be measured or guessed. Preventing a static discharge at a crucial moment during refuelling is very important. Creating a closed circuit between the aircraft, fuelling equipment and the ground, through static-line bonding, is therefore **absolutely imperative**.

Human Factors

There can never be any 'positive reinforcement' that a static fuel fire has been prevented every time an aircraft has been bonded, especially as we probably have not experienced a fuel fire on the occasions where we have neglected to bond an aircraft. It is therefore **easy to become complacent** about the need to static bond an aircraft.

All the factors mentioned above must be present for a fire to start as a result of a static discharge. This makes it rather a rare event. Because of this, the awareness of the hazards involved has tended to diminish over time. Static electricity 'cause and effect' is not usually emphasised enough during pilot and ground handler training, and it may eventually be completely lost as part of the formal training syllabus. Because we have 'got away with it' so often, some of us may have developed an attitude that we are impervious to the problem. Static by its very nature is **very unpredictable**, so it deserves to be treated with respect. The provision of proper training and operating procedures is very valuable in reducing the risks associated with refuelling.

Summary

Nothing is in equilibrium when refuelling an aircraft. The operation is dynamic by nature; fast fuelling speeds create sloshing and misting in fuel tanks. The faster the fuel transfer, the higher the risk of internal static discharge. The airspace, or ullage, in the fuel tank is rapidly changing at the rate the fuel is entering the tank. This constantly changes the air-to-fuel-vapour ratio as well as the temperatures and pressures within the fuel tank. Internal and external static discharge may therefore find the right combination for ignition at any time.

It is very important to remember that the pressures imposed by the modern refuelling environment can often bring the flashpoint of many aviation fuels way below that of the normal operating temperature range found at aerodromes around New Zealand. The risk of explosion is always present.

Aircraft materials and ground equipment are constantly being changed to meet changing operational roles. Some of these new operating procedures may introduce unknown hazards. Safe aircraft refuelling operations will always be more of a function of equipment design, proper handling techniques, and vigorous precautions, than the use of a particular type of fuel. The possibility of a fire or explosion created by static electricity is forever present – no matter how remote it may seem. ■

Pilot Rating Quiz

Question 1. What should I do if I have not flown a Piper Warrior (160 hp) for over six months and want to take a passenger for a scenic flight today?

I am a private pilot with around 100 hours total time, and I have flown four hours in the last three months on a Piper Archer (180 hp). My total time on both Piper aircraft is 20 hours. (I learnt to fly in Cessnas.)

Select the **most correct** option below that would allow me to take the passenger.

A) Not worry about the three takeoffs and landings in 90 days rule, because I am current on the Archer, which covers me for the smaller aircraft.

B) Do three takeoffs and landings with an instructor.

C) Do three solo takeoffs and landings.

D) Do a short dual check followed by three solo takeoffs and landings.

E) Do a short 30-minute refresher flight with an instructor.

Question 2. I have just completed a type rating that took two hours of dual instruction, which included a MAUW check, the completion of an aircraft technical sheet, and which was signed off in my logbook. Can I now take a passenger for a flight? Yes or No?

The answers to both of these questions are on page 7 of this issue.