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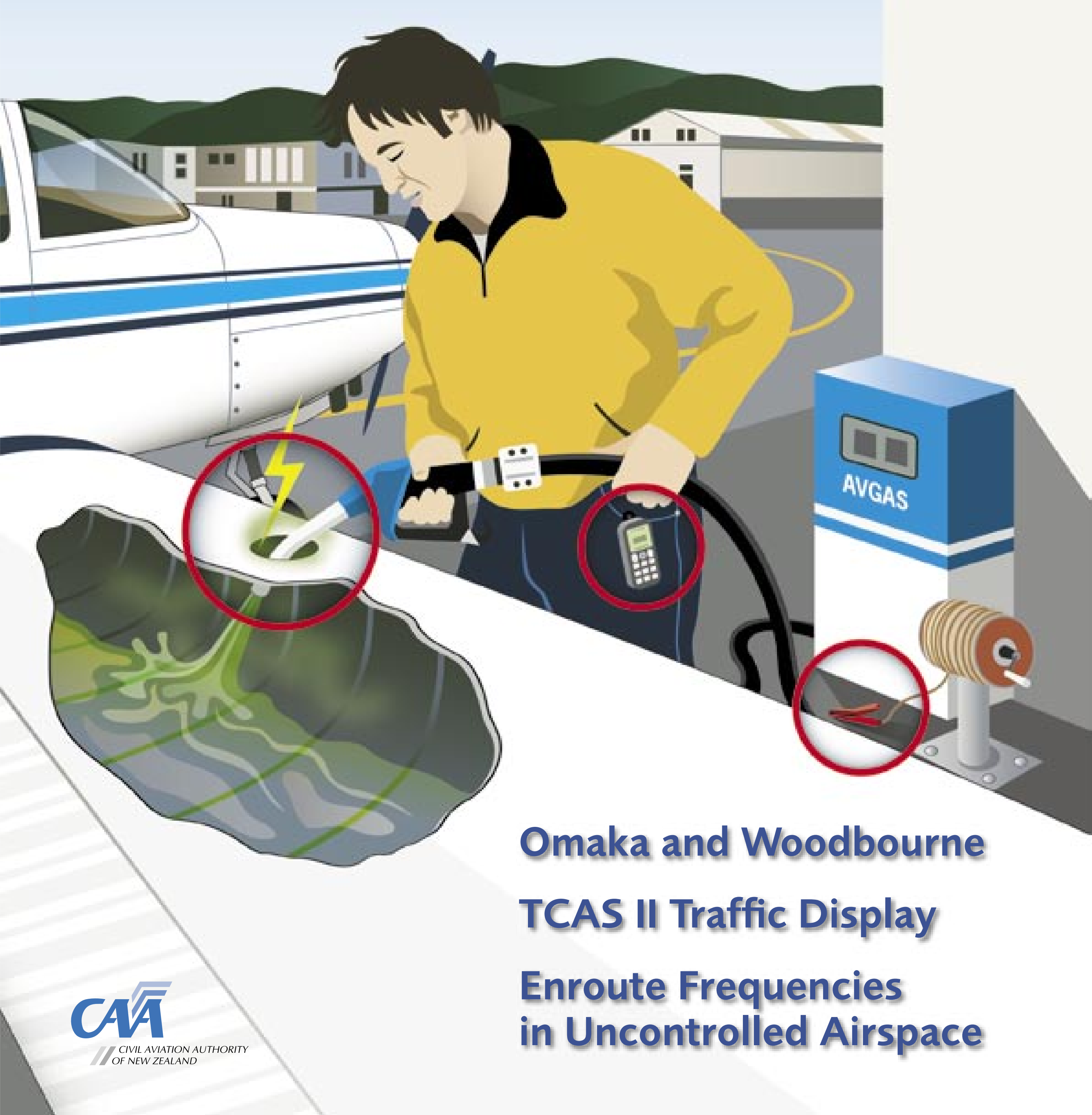
VECTOR

Pointing to Safer Aviation

Dangers of Static



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Dangers of Static

In June last year, New Zealand aviation had a dramatic and disastrous reminder of the dangers of static electricity discharge during fuel handling. While fuel was being poured into the empty tank of a Partenavia aircraft following extensive maintenance, an explosion occurred resulting in severe injuries to an engineer and extensive damage to the aircraft and surroundings.

We can carry out a refuel a hundred times or more without a problem, but static is very unpredictable and we should always be alert to the potential risk and take all possible precautions. Like many safety measures in aviation there is often no positive feedback that the precautions we are applying are definitely preventing an accident – but omit them, and the consequences can be sudden and permanent.

Accident Circumstances

As with most accidents, there was a combination of factors which added up to provide the opportunity for disaster.

Two engineers were preparing the Partenavia for test running of new engines. One of them was returning the fuel to the tanks which had been emptied for wing inspections. The aircraft was situated in the back of the large hangar rather than in the smaller workshop (with large adjacent doors) as it had been undergoing maintenance for some time, and would have tied up required space in the workshop.

Working in the cold hangar rather than the heated workshop, the engineer was wearing a synthetic polar fleece garment over his cotton overalls. To reach the fuel tank, he was standing on a metal ladder with insulated feet.

A plastic container was being used to transfer the fuel through a metal funnel with a chamois filter into the starboard tank of the Partenavia. (The plastic container was approved for flammable liquids, but for one use only.)

He proceeded to pour 10 to 12 litres of fuel into the tank when a huge explosion occurred inside the tank, blowing the top and the bottom out of the tank and the wing. A fireball erupted in both directions and the explosion blew the engineer off the ladder. He fell into the fire now burning on the floor. The fireball severely damaged the 6 metre high roofline and 75 square metres of roofing had to be replaced.

The aircraft was extensively damaged by explosion and fire.

Such was the magnitude of the explosion that a valued engineer and his family had their lives turned upside down for at least a year, workmates and friends were affected, and accumulated costs (direct and indirect) were estimated to be over half a million dollars.

The organisation involved is making all efforts to share the lessons learned, as similar scenarios could be happening in other maintenance workshops and aircraft hangars around the country.

The possibility of a fire or explosion created by static electricity is forever present – no matter how remote it may seem.

Some of the advice being shared with other organisations relates to obligations and investigation under the Health and Safety in Employment Act 1992. Any workplace accident resulting in serious harm will be investigated in terms of this Act, and the investigation will address actual and potential hazards, and the employer's means of addressing these.

Static and Fuel

Fuel is an extremely flammable liquid and explosive fuel/vapour mixtures may form at ambient temperatures. The presence of an ignition source can spell disaster.

Under certain conditions static electricity can be a potential ignition source.

The recent accident serves as a stark reminder of the potentially disastrous combination of static and fuel.

What is Static?

Static is experienced when materials, the environment, and our activities conspire to allow positively and negatively charged molecules to accumulate on different surfaces. If we then separate these surfaces, or move them relative to each other, a voltage difference will be set up.

Common examples of static build-up result from layers of clothing moving relative to one another, and also from contact with objects like car doors. There is generally no observable effect until the surfaces are separated; for example, clothing will start crackling only when garments are removed. Static can be generated when we separate our clothing surface from a car seat, which then leaves the car charged. We then provide a path for this accumulated charge to earth by touching the car door while standing on the ground, and receive a static shock.

Static and Aviation Fuel – A Bad Mix

Hydrocarbons, such as aviation fuels, are almost entirely made up of molecules which are not 'ionised' – that is, they are neither positively nor negatively charged. There are, however, some molecules present which are ionised – although the proportion

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is very small. In most situations these ionised molecules are undetectable.

These positively and negatively charged molecules will stay spread throughout the fuel, except where there is an interface with a different material, such as metal or plastic. In this situation, the charged molecules will separate and accumulate on different surfaces. The positively charged molecules will accumulate in the fuel and the negatively charged molecules on a surface – such as the inside of a metal pipe. This is not a problem, providing the metal and the molecules of fuel stay in contact.

If they separate, however (such as during refuelling), or move relative to each other, then the positively charged molecules are carried along with the fuel. This effectively means that there is an electric current flowing in the pipe. The negatively charged molecules will remain on the pipe, unless that particular part of the pipe is earthed, in which case it will be neutralised through a small current flow to ground. Thus a voltage difference is set up. As fuel itself is not a good conductor, this voltage difference remains, and it increases as the separation (ie, flow) increases.

Over a period of time these charges migrate and recombine with oppositely charged molecules – a process known as 'charge relaxation'. Eventually the voltage difference decays away to near zero, in a period known as the 'relaxation time' – which can be anything from a fraction of a second to a period of minutes. This means that the possibility of a static spark within a tank is always a short-term risk, following activity which has allowed the electrostatic field to develop. Relaxation times for avgas in light aircraft involved in refuelling will be very short – just a few seconds or less.

Ignition Risk

There is always the risk that static electricity might ignite a flammable material, such as avgas, causing a fire or explosion. Although such stored static energy is too low to harm us directly, the same amount of electrical energy, when dissipated in a spark, is more than enough to ignite fuel vapour.

A flammable air/avgas vapour mix requires only 200 microjoules of spark energy to initiate an explosion. This could be provided by a pulse of electrical energy consisting of a fraction of an amp at 50 volts, but static sparks are of surprisingly high voltage – of the order of 3000 volts per millimetre of air gap. Note that the minimum spark energy for ignition of Jet A-1 vapour is similar to that for avgas.

Identifying Static Hazards

Aviation fuels are handled in a way that makes accumulation and separation of charge more likely. Two examples of this are the use of very fine filters during product transfer, and the need for fast refuelling of commercial aircraft.

The use of fine filters during refuelling is unavoidable within the aviation industry. The effect of having a fine filter in a fuel line is to bring more fuel molecules in contact with the dissimilar material of the filter, resulting in higher charge separation. Fuel flow in a line with a very fine filter will typically generate 10 to 100 times the charge separation of the same line without a filter.

Another area of concern is the speed of fuel transfer though a refuelling hose, where higher speeds result in greater charge separation and more fuel splashing. Generally speaking though, a 'professional' installation will have features in place to minimise these effects.

If splashing or spraying occurs during the refuelling process (most likely during top-loading of a tank) a charged mist or foam can be produced, which results in a voltage difference between different locations within the same tank. Such a potential difference can be dissipated in a static spark – in the worst case. Other processes, such as steam cleaning a tank with flammable vapours still present, also produce charged mists and are therefore hazardous.

Other sources of static are synthetic clothing, and (possibly) cellphones. The latter has been cited as an urban legend, but don't put it to the test. Fuel companies still regard cellphones (or any transmitting device) as a potential hazard. Did you see those signs on the service station forecourt last time you refuelled your car? And the warning in your cellphone handbook?

Always be aware of other ignition sources such as smoking, naked flame, unshielded electrical devices, pilot lights, grinding-wheel sparks, to name but a few. There should be none of these within 15 metres of the aircraft or fuelling equipment.

Preventing Static Hazards

All pilots will be familiar with the routine bonding when an aircraft is refuelled at the pumps – the bonding cable is reeled out and attached to a convenient metal part of the aircraft. When refuelling from drums, always ensure there is a bonding lead connected to both the aircraft and the drum in use. Make the necessary connections before removing **any** fuel caps. Additionally, it is safe practice to keep the fuelling nozzle in physical contact with the filler orifice at any time fuel is being pumped.

Attaching the bonding lead is the first action when refuelling, and removing it the last.

Keep nozzle in contact with orifice while fuel is flowing.

This also applies to the filling of portable containers – place the container on the ground, and maintain contact between the fuel nozzle and the container. Approved containers (these comply with Australian and New Zealand Standard 2906:2001) have this instruction on the label.

The question then arises as to how to deal with the static hazard when pouring from an approved container into an aircraft. One suggestion is to bond the container to the aircraft before opening the caps on either; a jumper lead could be used here if there is no dedicated bonding lead available. Another possibility is to place the container in contact with the aircraft, again before any caps are removed, and maintain that contact throughout the refuel. Some portable containers have an integral pouring spout with which contact can be maintained. If a funnel is used, ensure that there is continuity between the container, the funnel and the aircraft.

Filtering fuel through chamois leather is not recommended. Studies have found that **the use of a chamois can be a static hazard,** synthetic chamois even more so. If the use of a chamois is necessary as a last resort, do exercise extreme care, and ensure all items used are electrically bonded.

A drum pump should be fitted with an appropriate in-line filter, and the delivery hose must be fuel-specific. Your fuel supplier will be able to advise on the correct equipment.

The 'Wrong Stuff'

A helicopter pilot in Australia watched the twilight refuelling of a company Islander at the end of a day's flying. The fuel was sourced from a drum sitting on the back of a utility; the hand-pump and in-line filter were standard issue, but the delivery hose was a section of clear compressed-air hose with integral reinforcing. A large loop of the hose hung down from the pump, in contact with the side of the drum. As fuel was pumped, a spectacular "sound and light show" of static sparks erupted along the length of hose touching the drum. Our intrepid pilot retired to a safe distance – but not before offering some fairly forthright advice on the safety of the refuelling operation.

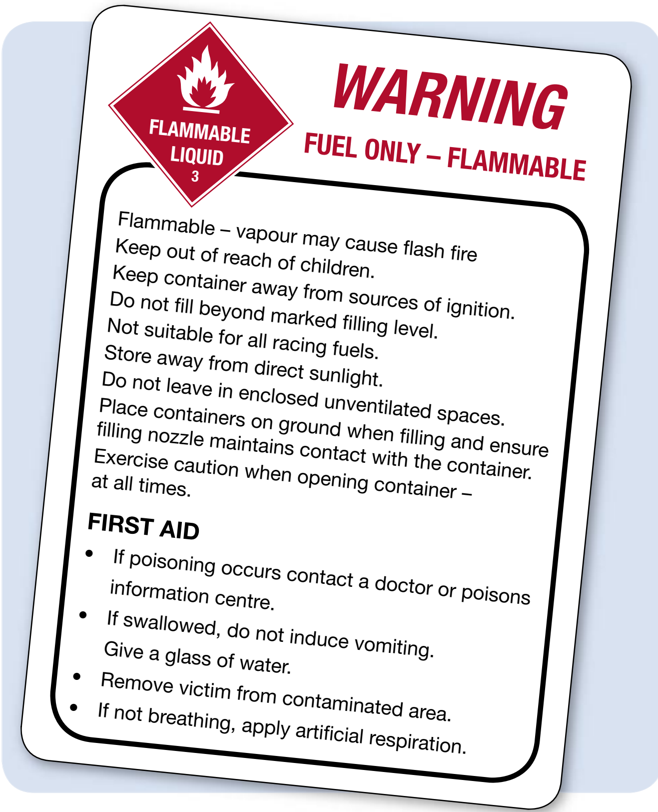
Be aware of the type of clothing you are wearing – some synthetics are especially prone to the generation of static, especially in the dry conditions encountered on frosty mornings, and in the classic nor'westerly conditions that east-coasters know well. Do not remove clothing near a refuelling operation.

The GAP booklet *Fuel Management* contains advice on fuelling procedures and precautions.

Beware of Out-of-Norm Situations

There may be a temptation to 'just drain a bit of fuel' – possibly if the tanks are over-full for a particular flight – into a handy clean container, then pour it back in later. (However, once the fuel is drained, it's never a good idea to put it back, regardless of the container used).

How do you know if you are using an approved container? Approved containers will have embossed on them the legends "Flammable", "Fuel Only", the capacity in litres with a mark indicating that level, a "LAB" number (an approval number issued by the Department of Labour) and a label complying with the Standard. Plastic containers meeting the Standard will be made of high-density polyethylene in a distinctive red colour.



Example label from AS/NZ Standard 2906:2001

Do **not** refuel or defuel inside a hangar or other enclosed space except in an emergency. Fuel vapour is heavier than air, and can flow a considerable distance (even down drains) to an ignition source. It can also 'pool' in confined spaces and remain a hazard long after refuelling or defuelling is finished.

Some years ago, a restored vintage aeroplane was being fuelled in an air-conditioned hangar (dry air), with all other known precautions in place, when a static spark ignited the fuel vapour. The aeroplane was destroyed in the resulting fire, but fortunately nobody was injured. The static spark was attributed to the type of overalls worn by one of the engineers.

Some workshops have used avgas as a cleaning medium, both in washbasin-type and compressed-air gun equipment. The latter practice is exceedingly dangerous, as the atomisation at the spray nozzle is a possible source of static in itself, not to mention the dispensing of large quantities of fuel vapour.

When in doubt — stop and think — and take all possible safety precautions.

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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 if we 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, and the day you think it won't happen could be the very day that it does!

Static electricity 'cause and effect' is not always emphasised enough during pilot, engineer and ground handler training. Because we have 'got away with it' so often, some of us may have developed an attitude that we are impervious to the problem.

Summary

A number of factors must be present for a fire to start as a result of a static discharge. This makes it (thankfully) a rare event. Because of this, however, awareness of the hazards involved can tend to diminish over time.

The possibility of a fire or explosion created by static electricity is forever present – no matter how remote it may seem.

Always remember these key points:

- Refuel and defuel outdoors.
- Ensure electrical bonding is in place prior to removing any fuel caps.
- Use only approved containers.
- Use only approved filters.
- When in doubt, consult your fuel supplier. ■

Further reading:

GAP booklet *Fuel Management*

NZ Flight Safety, Vol 16 No 2, September 1989 – "Do-it-yourself Refuelling"
NZ Flight Safety, Vol 16 No 3, December 1989 – "No Kidding"
NZ Flight Safety, Vol 17 No 1, March 1990 – "Playing with Fire"
Vector 1998, Issue 4 – "Static in the Fuel?"
Vector 1998, Issue 5 – "Static in the Operation"
Vector 1999 Issue 3 – "More on Static"
Vector, July /August 2002 – "Fuel Containers Ignite"

Material Safety Data Sheet (MSDS) for Avgas or Jet A-1 – available from your fuel supplier (or via an Internet search)

Radio Calls at Unattended Aerodromes

Most pilots will have, at some time, been uncertain from an aircraft's radio call whether that call represents traffic pertinent to the aerodrome they are at.

There are two main difficulties:

- Often, when concentrating on flying, and possibly with a high listening workload of mainly irrelevant information as can occur in areas where calls for more than one aerodrome can be heard, the first word of the transmission is missed – the vital word identifying the location. For example, in the Canterbury area there are three aerodromes and a busy training area on the same frequency. This can make it difficult to distinguish relevant aircraft activity in your area. When you are in the downwind leg at one aerodrome, a circuit call may cause a quick heart flutter and sky search when you didn't quite catch the first word, but then the runway direction means the aircraft is at another airfield, and you can relax again. This situation can be exacerbated by pilots talking too quickly, particularly in saying those important first two words.
- Sometimes, a pilot can be slow to depress the mike button and instead of a clear "Ashburton Traffic" we get just "…on Traffic". Again, one goes on full alert.

The uncertainty caused by both these scenarios could be removed by adopting the practice of repeating the aerodrome name at the end of the transmission. For example, "Rangiora Traffic, XYZ downwind [runway] 25 **Rangiora.**" Although wordier, it could alleviate possible confusion. This practice is common in the United States where pilots also identify what type of aircraft they are. This helps other pilots to gauge their speed and any possible wake, etc. For example, "Rangiora Traffic, Chieftain XYZ downwind [runway] 25 Rangiora".

At a busy unattended aerodrome where there is unlikely to be confusion with others, the repetition may be unnecessary on every call.

Another option is to adopt the practice used in Australia of preceding the location with the words "All stations". For example, "All stations Rangiora, XYZ downwind [runway] 25." The first two words get the listeners' attention and the third then prompts either more attention, or relaxation! Again, aircraft type should be included, at least for an initial call. This option is more of a change from our present practice, but would offer trans-Tasman consistency.

As the radio calls for unattended aerodromes are not governed by any specific ICAO phraseology standard, a change could be made reasonably easily for the New Zealand environment.

Vector would welcome readers' comments.