Static in the Fuel?

The following article has been contributed by Jane Lenting, Electrical Engineer for BP Oil New Zealand Ltd. It investigates the dangers associated with static electricity build-up during aircraft refuelling. Jane describes what precautions we can take, before refuelling our aircraft, to reduce the risks of a potentially catastrophic fire or explosion caused by a static spark.

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 – clothing will start crackling only when garments are removed, for example. 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 electricity tends to be associated with very high voltages – often over 10,000 volts – but only tiny amounts of current. Electrostatic fields temporarily set up with clothing and cars do not have sufficient stored energy to place us in any physical danger.

Static and Aviation Fuel – A Bad Mix?

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/vapour mix of Avgas requires only 200 micro-joules 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. Note that the minimum spark energy for ignition of Jet A-1 is similar to that of Avgas.

In New Zealand, Jet A-1 is generally less hazardous than Avgas because of the lower environmental temperatures that we experience relative to many other countries. The risk of Jet A-1 reaching flash-point and igniting is slightly reduced because of this. Local temperatures need to be above 38 degrees Celsius before the vapour above the liquid fuel surface forms a flammable air/vapour mix that will sustain an explosion. **Jet A-1 still needs to be treated with respect**, however, in terms of avoiding any contact with an ignition source. Why? Because tarmac temperatures can rise above 38 degrees Celsius at some aerodrome locations around New Zealand.

Photo courtesy of BP Oil New Zealand Ltd.

Why Does Static Build Up In Fuel?

Petroleum fuels are generally poor conductors of electricity. This low conductivity allows an accumulation of charge – and fuel itself does not instantly dissipate any charge that has built up.

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.

Although static electricity is of concern throughout the petroleum industry, the handling of aviation fuels presents special risks that can be reduced by fuel specification, equipment design, and operating procedures – these are discussed later in the article.

What Is Happening On a Molecular Level?

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. However, there are some molecules present which are ionised – although the proportion 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 bonded to earth, 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.

Identifying Static Hazards

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.

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.

"The most effective method of preventing static build-up during refuelling is to bond the aircraft."

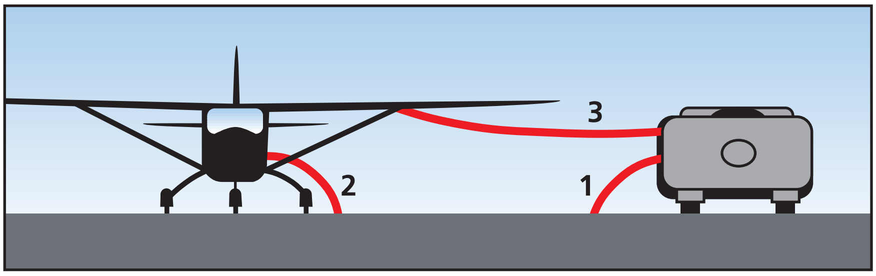
The use of fine filters during refuelling is unavoidable within the aviation industry. The effect of having a fine filter in a fuel line is to bring more fuel molecules in contact with the dissimilar material of the filter, resulting in higher charge separation. Fuel flow in a line with a very fine filter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

Preventing Static Hazards

Ignition caused by static discharge is infrequent and preventable. Between 1953 and 1971, there were 35 aircraft accidents involving fire and explosions attributable to static discharge. Since the mid 1970s, reports of such incidents have been greatly reduced by the use of some important static mitigation designs and procedures that have become widely used.

Aircraft Bonding

The most effective method of preventing static build-up during refuelling is to bond the aircraft. By bonding we mean connecting the metal structure of the aircraft to earth – via a cable or other conducting path. Bonding itself will not prevent the accumulation and separation of charge (and therefore the development of a voltage difference) between the fuel and the surface it comes in to contact with during refuelling. However, by the time refuelling has stopped, and the relaxation time elapsed, the bonding connection will have safely dissipated the charge that has accumulated on the inside surface of the refuelling hose and nozzle, as well as any charge which has accumulated on the aircraft during flight.



The diagram shows the correct way in which to bond an aircraft during refuelling to ensure that a static potential does not build up.

A failure to connect the bonding cable, and to leave it connected until refuelling is complete, may mean that the conditions exist for a spark to be generated between the refuelling nozzle and the aircraft tank fill point. The area near the entrance to the fill point is likely to contain fuel vapour within the flammable range, and if it does, this spark will have a good chance of causing ignition.

Bonding of the aircraft before refuelling is accepted procedure for all types of aircraft. It is up to the individual pilot (or the ground refueller) to appreciate the reasons for this procedure and to apply it consistently with every refuelling.

Anti-Static Additives

The introduction of additives which increase the conductivity of aviation fuels has been one of the most significant developments historically. These additives do not prevent charge separation – in fact they increase it. However, they reduce the relaxation time by changing the fuel conductivity, and they almost eliminate the possibility of this charge separation being dissipated as a spark within a tank.

Without the anti-static additive Stadis 450, Jet A-1 would have a greater static risk than Avgas at ambient temperatures above 38 degrees Celsius. This is because the conductivity of Jet A-1 without the additive is lower than that of Avgas.

Fuel Velocity During Transfer

Oil companies use industry guidelines for maximum fuel velocities that relate to the pipe diameter and the type of fuel. Typical values might be around one metre per second until the inlet point is covered by fuel, and up to seven metres per second for the remaining refuelling operation. Lower fuel velocities also mean less foaming and splashing, thereby reducing the risks of producing a charged mist.

Filter Design

Experience has shown us that unfavourable filter design can result in increasing charge separation. It is wise to check that your aircraft refuelling system has the approved fuel filters fitted in order to reduce the chances of static build-up.

Ensure that your aircraft refuelling system has the approved fuel filters fitted so that the chances of static build-up are reduced.

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Summary

It is worth making the effort to ensure that your aircraft is correctly bonded while refuelling. It takes only the smallest of sparks to ignite aviation fuel during the refuelling process, causing a fire or explosion. Hot and dry atmospheric conditions pose the greatest risks and mean that extra care is needed – especially on a northwest day for example.

Vector Comment

Other safety tips that *Vector* recommends you adopt when you are next involved in refuelling an aircraft include:

- Make sure that the bonding cable is in good condition and is securely attached to a clean metal surface that will conduct current easily.
- Avoid using any electrical devices around the aircraft while refuelling is occurring – the risk of dropping a portable phone or radio resulting in a spark is not worth taking.
- Be careful about introducing other sources of static while refuelling, such as may be present on clothing. Avoid wearing items like nylon jackets, and certainly do not remove them while refuelling, as this may result in a static charge build-up.
- Ensure that you know where the fuel pump emergency cut-off switch and fire extinguisher are.
- Release the aircraft brakes (this particularly applies to light aircraft) so that you are able to push the aircraft away from the refuelling source if a fire does occur. ■

Annual VFG & Chart Editions

The following notification has been prepared by Aviation Publishing, who are responsible for the production and distribution of the VFG, charts, and other New Zealand AIP documents.

From July 1998 the VFG, VTC charts, 1:500 000 charts, and enroute charts will be published annually – making it easier and cheaper to stay up to date.

This was decided after consultation with Aviation Publishing customers and the CAA (who are responsible for the development and design of airspace). Customer consultation was achieved via an Aviation Publishing customer survey and roadshow. Cost and frequency were found to be important issues for many subscribers.

For VFG subscribers, this will mean a reduction in annual subscription costs from $83 to $75. This subscription fee will cover the production and distribution of the VFG, AIP Supplements, change notices and AICs. These additional products will continue to be sent out every four weeks throughout the year as per normal.

While the price of the VFG has been reduced, the price of charts will increase slightly. In the past the costs of producing charts were offset by subscription funds held in advance. Now, with only one edition each year, this is no longer possible. Customers will still notice a considerable cost saving, as they now only have to purchase charts once a year.

The extent of the savings passed on to you will depend on what products you purchase. The following comparison is given for a customer purchasing the VFG, VTCs (both AA/OH and WN/CH) and two 1:500 000 charts.

Product	Old price	New price
VFG	$83.00 (2 editions)	$75.00
Auckland/Ohakea VTC	$25.00 (2 editions)	$18.00
Wellington/Christchurch VTC	$25.00 (2 editions)	$18.00
1:500 000 charts (per sheet)	$28.00 (2 editions)	$20.00

For the combination of products tabled above, the old price was $189 per year - it will now be $151 meaning **a saving of $38 per year**.

The change to annual editions for the VFG and charts will occur on 6 July 1998, creating a standardised subscription period from July to June of each year. This ensures no inconvenience to the majority of customers who already have current VFG and chart subscriptions over this period. Customers whose subscriptions expire with what would have been the December 1998 edition of the VFG, can pay to continue their subscription through until July 1999 (and continue to receive Change Notices, AIP Supplement and AICs).

The new subscription period also means products that become effective in July will remain current throughout the busiest general aviation period – daylight saving months. This also allows changes to be made to the VFG and charts at what is traditionally a quieter time of the year.