# SAFE HANDLING of 'LIGHT ENDS'

## BY JIM WILLS

*Jim Wills, a professional fireman, is the Cranfield Rally's Chief Fire Officer. Here, he outlines the dangers of refuelling aircraft, without the correct precautions being taken, from anything other than an approved installation and suggests a method by which PFA members can obviate some of the hazards.*

In our modern motorised society most of us, at one time or another,are likely to have treated fuelling operations on our daily transportation devices with an abandonment bordering on contempt, by paying the operation no more attention than would be given to picking up the milk from our doorstep. Obviously we know that we should not smoke while refuelling and are reminded of the fact by prominent notices displayed on petrol station forecourts. Accepting that proviso, we merrily continue with the operation in the belief that our safety is assured. For the most part this is so — but not by accident. Motor manufacturers, and the petroleum industry in general, have built up an in-depth knowledge of the hazards that are an inseparable feature of petroleum spirit. Their combined knowledge and efforts have produced the safety in vehicles and fuelling equipment that we take so much for granted in our everyday lives.

While we carry out fuelling operations in such cosseted environments it is not essential to know the why's and wherefore's because all that has been looked after for us. Substitute that environment for one lacking recognised safety measures, e.g. your typical farm strip, add to it one small insignificant aeroplane able to hold even less fuel than a medium sized car and destiny is literally in YOUR HANDS! Be sure to understand the inherent hazards involved when dealing with petroleum spirit and take the necessary steps to avoid them.

Firstly it is necessary to understand the 'Triangle of Fire' — draw your triangle of three elements: FUEL : OXYGEN : HEAT. Remove any single element and fire cannot support itself. Under certain conditions, the flow of petroleum spirit through a nozzle and into a tank can cause an electrostatic charge to be built up. This phenomenon is aggravated where the charge of steadily rising voltage is prevented or hindered from passing safely to earth through a circuit of low resistance. Such a situation can be imagined if, for instance, one wished to refill a metal tank or container which, for whatever reason, had been placed upon dry timber. The refuelling nozzle, because of incompatible size would not fit into the container so, to prevent splashing all over the place, a funnel has to be used, which just happens to be made from a plastic material.

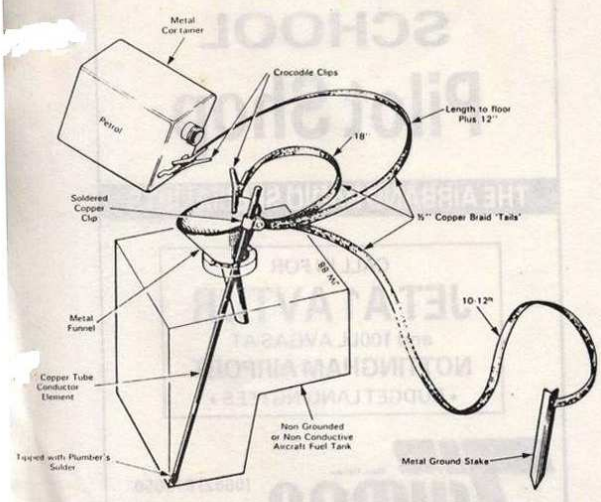


*Fig 1. Static Ground Conductor for safe refuelling.*

The container had previously held petrol but was empty. Or was it? Look closely at the filler opening towards a bright light. There is a quivering haze, which you will recognise as fumes. These are known to the petroleum industry scientists as 'Light Ends', the container is full of them AND OXYGEN and is in its most dangerous condition. It needs only the heat from a naked flame or spark. As petrol is poured in, static electricity is produced, initially in small quantities but building up. It wants to get away, but finds no easy route of low resistance. It continues building up all the time fuel is being poured in, until it has accumulated sufficient energy to overcome the high resistance in the container's earth path, at which point the discharge, resembling fork lightning, will occur between the path of the fuel and the closest part of the container. If, at that point, there is sufficient 'space' (filled with Light Ends and Oxygen) within the container an explosion will occur. Alternatively if the quantity of liquid petroleum had displaced the Oxygen within the container (i.e, it was full) then the Light Ends above the surface and able to mix with Oxygen would be ignited. This hypothetical scenario would be a recipe for disaster and the use of a plastic container could only make matters worse!

Motor manufacturers, and the petroleum industry, recognise these hazards and construct their respective products to prevent such occurrence taking place. Fuel tanks are made in such a manner that the tank structure is conductive, and are mounted so that a low resistance path to the vehicle's common earth member — the bodyshell — exists. In turn, the bodyshell is 'grounded' through electrically conductive tyres.

Petroleum industry safeguards are governed throughout the whole refining process right through to the retail outlets. Take for instance the regular petrol station pumps — the fuelling nozzle — still made of steel (where many former steel products are now made from plastics!). Reason: earthing or grounding. The nozzle itself is angled! Why? To ensure that at least part of it remains in electrical contact with the tank filler neck so as to provide an earth leakage path. The delivery hose is conductive for the same reason, and lastly, the pump itself is grounded. So there.we have a completely earthed delivery line with all these safeguards built-in to prevent the possibility of a static electrical discharge.

Now enter upon the scene the aircraft builder and operator — you, me, or Tom from down the road. When mentioning electrical grounding, two replies recently heard indicated a less than complete understanding of the problem: 'Oh I fly non-radio, doesn't affect me', and 'My hand-held has no provision for grounding'. Radio interference suppression is only one reason for grounding

but the main reason has to be SAFETY – which is more at risk when refuelling than at any other time.

Our line of thought should be towards bonding together electrically all major metal components to form a common ground; engine bearer, power unit, fuel tank/s, and undercarriage, most especially on non-metal aircraft, so that we have an earth leakage path of LOW RESISTANCE. Use a good quality Multimeter to check between all points,and aim for zero resistance.

On standard production aircraft, the most convenient place to put the crocodile clip from a refueller's earth cable is onto the exhaust pipe. It presupposes that the manufacturer has interconnected all components, and he usually has, but what about that 'used' vintage job you fly? Get out the Multimeter and check it, or find a person that can, then if it is found wanting do the job promptly for your peace of mind, because later may be too late!

The fuelling operation itself should always be undertaken with great care. Ensure that the aircraft is prevented from moving, either by the use of chocks or brakes, then attach the 'ground' lead. Make sure that the tank filler is within comfortable reach, if it is not then use steps so that proper control of the fuelling nozzle is maintained. The longer one has to hold it, the heavier it appears to get. The fuel nozzle itself, like its automotive counterpart, is fitted with an angled metal outlet. For the same reasons it should always be in contact with the tank neck, but more care is needed here because the lengthy and substantially constructed hose can be relied upon to exert considerable leverage forces on the nozzle which are easily capable of bending the neck. Give the hose plenty of support to relieve the weight and, when peering into the filler orifice to check contents, **always shut off fuel flow** before partially removing the nozzle. Before recommencing the fuel flow, make sure that the nozzle is again in contact with the tank neck. With fuelling completed, refit the tank cap securely (some types of cap are fitted with a 'standpipe' vent and are capable of being fitted the wrong way round – the standpipe orifice should always face forward into the airstream). If fitted the wrong way round, a vacuum instead of a positive pressure would be created which could result in fuel starvation and possible siphoning of the contents in flight. Lastly, when fuelling is completed, a check should always be made to ensure that the Ground Lead has been removed.

The inherent characteristics of petroleum spirit I have described will not go away like a bad dream, indeed they can even be exacerbated by the radiant heat of a hot day. Therefore, like the commercial manufacturers, we as builders must recognise and come to terms with the problem and take steps to avoid it. With small and often composite designs where weight saving is all important, the more likely it is that a designer has chosen a non-conductive material for the manufacture of the tank. Where such design is called up to be built-in there is no choice in the matter. Therefore, a modified approach would be more appropriate, which also suits the aircraft sited on a strip and remote from approved fuelling equipment, where recourse may have to be made to portable fuel containers filled by one's nearest airfield fuel supplier.

Without too much ingenuity a builder or operator can easily make up an efficient 'Ground Conductor' device which is easily stowable within the aircraft as follows: (See fig. 1)

Select a suitable length of ¼" o.d. copper tubing (as used on microbore central heating systems) so as to allow 3 inches of its length to protrude from the open tank filler neck when the remainder slants within the tank to its most extreme angle. With the tube back on the work-bench, fabricate a clip from a larger piece of copper tube slit down its wall and fit this to the top end of the Conductor Element (which the ¼" tube has now become!). Reverse the element and melt plumbers solder into the bottom end, then dress it to form a bullet shaped tip. This tip will prevent damage to the tank bottom. Next, obtain 20 feet of ½" wide copper braid from a good electrical supplier, also a 'Ground Stake' of some 12" in length in any convenient form (remembering that it may need to be hit as well as handled). Certain tent pegs made of steel are suitable but bear in mind the compass when stowing. Measure the distance from the tank top to ground level then add 12" and cut this amount from the length of braid. Cut a further 18" piece of braid, taking one end from each length (3 in all), assemble these to the clip at the upper end of the conductor element, initially by bolting with a 3/16" bolt. Fasten the free end of the longest braid tail to the Ground Stake and, to the remaining two braid tails, securely fit heavy duty crocodile clips. Finally, using electrical solder, solder the clip to the Conductor Element, and the braids to the clip.

In use, the Ground Stake is embedded as deeply as possible, the short lead is clipped to the (metal) funnel and the remaining lead is clipped to the (metal) refuelling can. As can be seen from the sketch the whole path for the discharge of static electricity is now safely led to ground. This small additional chore when filling will be repaid with the peace of mind and knowledge that tomorrow you will still have an aeroplane to fly.

**RULES**

1. Always ensure proper Grounding has been made before refuelling.
2. NEVER use non-conductive containers.
3. NEVER use non-conductive funnels.
4. NEVER wear a nylon jacket or anorak. In dry air, nylon can generate a lot of static electricity which can jump a sizable gap. There are several recorded cases of aircraft being destroyed by fire started through wearing nylon clothing whilst refuelling.