BRITISH MICROLIGHT AIRCRAFT ASSOCIATION

TECHNICAL INFORMATION LEAFLET

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INSTRUMENTATION AND AVIONICS

1. Introduction

1.1 All aeroplanes, whether microlights or otherwise have some kind of instrumentation fitted. BCAR Section S as a minimum requires that a microlight should be fitted with an altimeter and ASI, along with the minimum engine instruments required by the engine manufacturer. Most microlights will also have a compass fitted, and increasingly fuel pressure, coolant temperature, rate of climb or other instruments. The minimum list of instruments for any particular type is listed on the TADS or HADS for the aircraft.

1.2 This TIL aims to give advice on the fitting of instruments to microlights. It should be used by aircraft owners when installing new instruments, by homebuilders, and by inspectors to ensure that best-practice has been followed wherever possible. It covers as widely as possible the instrumentation which may be fitted to microlights, although cannot possibly be exhaustive; therefore in some cases other TILs may be referred to. If no advice can be found concerning a device which is to be fitted to a microlight in this or other TILs, or advice given here is disagreed with, please contact the BMAA Chief Technical Officer, in writing wherever possible.

1.3 It must be borne in mind that microlights are still simple aeroplanes, and although some owners may wish to do everything possible to ensure that their aeroplane is perfect, others may not wish to - and it is important to realise the difference between "good enough" and "best". Therefore, against each part of this TIL there are two sections, marked "Essential" and "Advisable". The "Advisable" section details the sort of best practice which is almost certainly applied to larger aircraft with a full Certificate of Airworthiness but need only be applied to a microlight at the owner's discretion. Nonetheless, for homebuilt or major rebuild / redesign projects, it is strongly advised that the owner and inspector review these sections, so that if that advice is disregarded it is done so consciously and for good reasons, and not simply ignored.

1.4 Inevitably there are older designs (and sometimes their more modern derivatives) which will not conform to the requirements of this TIL. Inspectors are cautioned against getting carried away with this, unless something is actually dangerous. If it matches the original design standard it should be left alone; however, if any changes are made later to the aircraft, then any changes should comply with current practice, as described herein.

2. Other Sources of Information

2.1 BMAA Technical Information Leaflet TIL 007 describes the requirements for fuel/ignition systems and ignition wiring.

2.2 BMAA Technical Information Leaflet TIL 013 describes the wiring and switching requirements for strobes and anti-collision beacons.

2.3 BMAA Technical Information Leaflet TIL 016 is regularly updated and gives advice on what the BMAA will accept with regard to compliance with BCAR Section S.

2.4 BMAA Technical Information Leaflets series '100' contains information on fitting common items such as GPS, radios, etc.

3. The Instrument Panel (see figure 1)

3.1. Description. The instrument panel is any area in which instruments are mounted. Most commonly this will consist of a flat panel of aluminium or fibre-glass, although occasionally plywood, fibrelam or painted steel are also used.

3.2. Essential Requirements.

3.2.1. There must be enough space around instruments fitted that there is adequate mechanical strength left in the panel to carry the additional weight. Obviously this means that with a thick metal panel instruments can be far closer together than with the same thickness GRP panel for example. As a rule, you should be able to push on each instrument with 9 times its weight without any undue panel deformation, and on the whole panel with 9 times the total weight. This of-course means that more space is likely to be required around a heavy instrument than a light one. Having said that, instruments with backing plates which are screwed into the panel are unlikely to have a significant weakening effect.

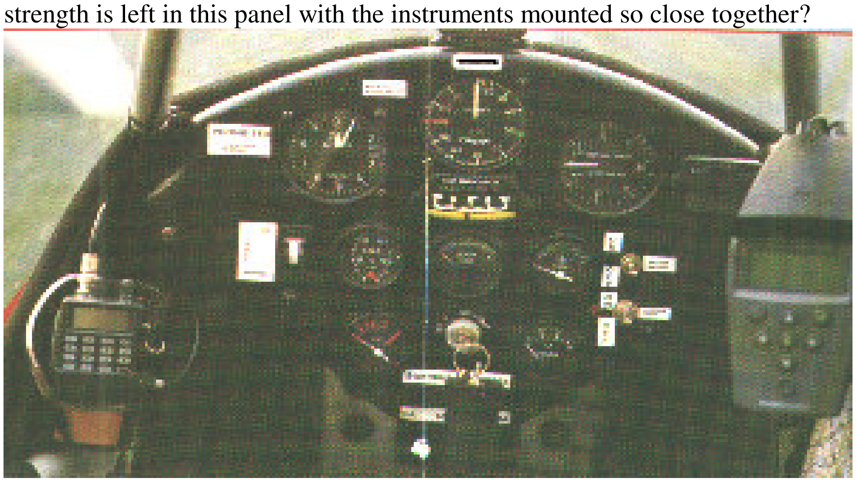
3.2.2. The most important instruments (ASI, Compass and altimeter) should be positioned directly in front of the pilot so that he or she can see true readings, and not those confused by parallax error.

> Parallax Error
>
> Because the scale on a gauge is below the needle, the true reading will only be obtained when looking straight at the dial. If you look at the gauge from a slant, the needle will appear to be over a different part of the scale, giving an incorrect reading. This is the parallax error.

3.2.3. If more than one engine is fitted, engine switches must be grouped so that it is very clear to which engine each reading refers.

3.2.4. All switches and adjustments (including the altimeter subscale setting) must be reachable by a small adult whilst strapped into the pilots seat. Shadow aircraft, where the pilot's body is a long way from the instrument panel, usually use a piece of stiff hose as an extension to the altimeter subscale setting knob to permit the pilot to adjust it in flight, although not ideal this is an acceptable solution.

Figure 1
An example of a well laid-out panel, backup lanyards are fitted too, but one has to ask how much residual strength is left in this panel with the instruments mounted so close together?



3.2.5. If a new instrument panel, or additional instruments, are fitted to a 3-axis microlight, the W&CG must be checked.

3.2.6. Anything fitted into an aircraft must be secured. Items simply resting in a cradle, or fixed with a light friction fit are not acceptable. Items fitted with Velcro, unles extremely light (e.g. electronic stopwatches) must have a secondary restraint (lanyard). Lanyards must not be long enough to interfere with flying controls, or entry and exit to the aircraft.

3.2.7. Unless there is no choice (i.e. it is permanently attached to an instrument) do not use single cored wires, always use multi-strand wires which are much less prone to breakage.

3.2.8. There mustn't be any long pieces of unsecured cable, particularly near to the pilot and passenger where they could become caught on it when trying to exit the aircraft.

3.2.9. Confirm that the instrument panel is not part of the primary load path of the aircraft (which it is in a few designs), in which case no more holes than permitted by the construction manual or type approval holder should be cut. Equally, don't replace such a panel with a less substantial material.

3.3. Advisable Requirements.

3.3.1. If instruments are provided with a secure fastening method, such as a clamp or screw these should be used. Securing of instruments using an adhesive such as Araldite should be avoided, although some instruments (such as slip balls) are designed to be "stuck" onto an instrument panel and this is unavoidable.

3.3.2. Normally an instrument panel will be fitted using some form of readily removable screws or fasteners so that easy access is available to the rear of the instruments. In order for this to be useful, either cable lengths must be sufficient behind the panel to allow it to be lifted out, or some form of quick release must be fitted.

3.3.3. Engine instruments should where possible be grouped together.

3.4. Designing an Instrument Panel.

3.4.1. It is advisable before making up an instrument panel to make a full size mock-up using stiff cardboard. This can be done cheaply and easily, and then fitted in the cockpit with the instruments in to allow the owner to satisfy themselves that the instrument layout is appropriate, and that there are no interferences behind the panel which had been missed.

3.4.2. The primary flight instruments should ideally be in a position where they can be examined quickly as part of the instrument scan without the pilot having to move their head or change focus any more than can reasonably be avoided.

3.4.3. The compass should be located away from electrical gauges (ammeters, tachometers, etc.) since these contain magnets which will adversely affect compass readings.

3.4.4. Also consider the wiring path, it must be adequately secured throughout its length, and no wire or cable must ever be attached to a fuel hose or run past or across fuel drains or vents.

4. The Pitot-Static System

4.1. Description. The Pitot static system has two sources of information and up to three instruments reading from it. Some microlights use venturi airspeed indicators, rather than pitot type airspeed indicators, these are described separately.

4.1.1. The **Pitot head** (figure 2) measures the *pitot* or *dynamic* pressure. It normally consists of a tube or hole pointed into the airflow. It feeds into the airspeed indicator.

4.1.2. The **Static Port** measures the static pressure, that is the pressure which would be measured in still air, or perhaps from a balloon, at the same height. It provides a reference for the altimeter, ASI and the vertical speed indicator (VSI) if fitted. On some slow open-cockpit microlights (e.g. trikes) the static source may well just be open vents on the back of the instrument panel. Some older microlights with enclosed cockpits also have static sources inside the cockpit, but this has caused considerable problems and is rarely acceptable in new designs: even if corrections to the ASI can be made, altimeter errors due to airspeed can also be introduced. In a completely open cockpit, it must be ensured that the back of the altimeter isn't facing directly into airflow, otherwise it will simply act as a pitot!

4.1.3. The **Airspeed Indicator, or ASI** is a pressure gauge which measures the difference between the pitot and static pressures, from which it determines airspeed (which is proportional to the *square root* of this pressure difference). It displays Indicated Airspeed or IAS, which must be corrected for system errors to give Calibrated Airspeed, or CAS (also known as Rectified Airspeed, or RAS). CAS in turn must be adjusted for altitude to give True Airspeed or TAS (which is then added to the vectored wind speed to give Ground Speed, or GS). Flight limitations are always given in IAS, not any other speed. An ASI normally reads in knots, although many still read in mph - to obtain knots from mph divide by 1.15.

Figure 2

This picture of an Ultraflight Spectrum shows an aerodynamically well-positioned pitot (1) and the port side of two matched static ports (2). A guard or streamer is however prudent on the ground for such a pitot-head to prevent 'hangar rash'.

4.1.4. The **Altimeter** is a pressure gauge which measures the static pressure, and from which determines the *pressure altitude*. To adjust for atmospheric variations it will normally have a subscale setting which can be adjusted in flight. This will normally be set to QFE (to read zero on the runway), Local QNH (to read mean height above sea level on the runway), Regional QNH (an area minimum QNH, normally provided by air traffic services for use on cross-country flights), or QNE (1013.25mb, a standard setting used for traffic separation at higher levels). An altimeter will normally read in feet.

4.1.5. The **Vertical Speed Indicator, or VSI** is a device which measures the rate of change in static pressure, and expresses it as a rate of climb or descent, usually in feet per minute.

4.1.6. The **Hose** connecting the parts up should be as short as possible and tested before first flight after installation, maintenance or modification for leaks. Unlike fuel systems, it is permitted to use PVC hose in pitot-static systems.

4.2. Essential Requirements.

4.2.1. The pitot head should be in clear air ahead of any obstructions.

4.2.2. Aircraft with an enclosed cockpit, or a semi-open cockpit judged likely to create pressure effects, must have a static source outside the cockpit.

4.2.3. On 3-axis microlights an outside static source should be balanced by holes or plates either side which are connected to each other. This prevents errors due to sideslip (which might otherwise lead to height and speed indication errors in a side-slipped approach, for example).

4.2.4. If the static source is an open cockpit vent on the back of the instrument panel, this must be uncovered and unobstructed.

4.2.5. All hose connections must be securely made, preferably using clips designed for the purpose. Take care that the hose layout doesn't allow crushing or kinking of the hose.

4.2.6. If the pitot static system is altered (e.g. either the static source or pitot head design/location is changed) the system must be recalibrated. How to do this is described in 4.4 below.

4.3. Advisable Requirements.

4.3.1. Inside static sources should have a protective gauze covering them to prevent insects or dirt entering.

4.3.2. Outside static sources on painted aircraft should have a sign adjacent to them warning "NO PAINT" or words to that effect.

4.3.3. Pitot heads should have a cover to prevent insects, dirt or water entering them whilst the aircraft is parked. It is normal for such covers to have a brightly covered tag attached so that the pilot does not forget to remove them before flight.

4.3.4. An altimeter should be fitted with an adjustable subscale in millibars, which has been checked and, if necessary calibrated, against a known good instrument (one is to be found in the tower of most licensed airfields). Since air traffic services in the UK do not provide altimeter settings in.Hg, or mm.Hg, only millibars are suitable.

4.3.5. The airspeed indicator should have been calibrated and a correction card displayed if errors are more than 3 knots out at any point in the operational range (V_{S0} to V_{NE}).

4.3.6. Pitot heads should be located where they are not too prone to suffer from “Hanger Rash”. If they are brightly coloured, this also will help reduce the risk of damage since they become more visible.

4.4. How to Calibrate a Pitot-Static System.

4.4.1. The altimeter should be calibrated on the ground against a known good altimeter. Generally, altimeters only have one adjustment available, so the best that can reasonably be done is to ensure that your instrument shows zero with the correct QFE set on your home airfield.

4.4.2. Having completed a BMAA homebuilt, then the aircraft’s limitations will probably be recorded on the HADS as CAS (Calibrated AirSpeed). If you are replacing or changing the pitot-static system on an existing microlight for which the CAS limitations are not known, the airspeed calibration must be carried out first with the old system, so that the flight limitations are then known as CAS (normally they are only placarded and shown in the HADS / TADS & manual as IAS).

4.4.3. A source of “truth data” will be required. It will be assumed here that a handheld GPS is used, which will normally give airspeed values accurate to within ±0.3kn, which is quite adequate for these purposes. If possible, fly with an observer so that the tasks of watching the GPS, flying, writing down notes, and maintaining a safe lookout can be divided between you. As with all flight testing, it should be done with 1013.25mb set on the altimeter; if you are flying non-radio, don’t forget to note your QFE before you change it!

4.4.4. Decide upon a safe flying height, at which you are clear of turbulence and are able to stay for a reasonable period of time. At this height, determine the exact wind direction using the GPS - if you fly into wind at a constant IAS, the wind direction is the heading at which the GPS reads the lowest ground speed.

4.4.5. At a range of indicated airspeeds between just above the stall and V_{NE}, fly at the fixed height into wind, noting the stabilised GPS groundspeed each time. At higher speeds, this will have to be done in a descent, in which case using a stopwatch time how long it takes on these occasions to descend through 200 feet, and record this also (note the changes to columns (d) and (g) below if the aircraft is or isn’t descending).

4.4.6. Now repeat this exercise flying downwind (caution, you will cover a lot of ground very quickly doing this).

4.4.7. Once you’ve landed, then put all this together in a table, together with some analysis (you’ll need a good calculator for this). Form BMAA/AW/043, available from the BMAA website, is a pro forma for recording and analysing the data.

4.4.8. Now it’s possible to plot a graph of IAS (in whatever unit your instrument reads) against (usually knots) Calibrated Airspeed.

4.4.9. If CAS operating limits have previously been determined, this graph can now be used to determine what **indicated** limitations should be placarded in the aircraft. It can also be used to put a correction placard in the cockpit allowing Calibrated

Airspeeds to be worked out in flight for navigation purposes. An example placard is shown in figure 3 below.

5. The Compass

5.1. Description. The compass is a magnetic device fitted to allow the pilot to work out his magnetic heading, usually consisting of a sphere containing a magnetic needle, suspended in a liquid. It is not the same as a direction indicator, which is a device often fitted to light aircraft and not described in this TIL.

5.2. Essential Requirements.

5.2.1. If secured by screws, compasses must be fitted using non-magnetic, (normally brass) screws.

5.2.2. The compass should be fitted as far as practically possible (perfection is inevitably impossible), away from anything which may create a magnetic field. This includes batteries, voltmeters, ammeters, EGT / CHT gauges, tachometers, power cables and large steel components.

5.2.3. If a compass is suspected to contain errors of more than 5°, a compass swing must be carried out. (This is a requirement of BCAR Section S, para S1547).

5.3. Advisable Requirements. It is recommended that a "compass swing" is carried out and a correction placard fitted.

5.4. How to carry out a compass swing.

5.4.1. Position the aircraft well away from any electrical or magnetic interference (e.g. in the middle of a field).

5.4.2. Using a separate magnetic compass (which is known to be correct) well away from the aircraft, identify the main compass headings (you need to do this right around the compass in increments of no more than 30°) in a way that will permit you to point the aircraft in the right direction for each heading.

5.4.3. Applying all normal safety precautions (e.g. pilot strapped in and if appropriate wearing a helmet, clear of FOD and bystanders, hearing protection if necessary), start the engine and switch on all equipment normally operated in flight (e.g. strobes, radio, electric carb heat, etc).

5.4.4. Pointing the aircraft to each correct magnetic heading, note the indicated compass heading.

Figure 3 - Typical Airspeed Correction Placard

kn CAS	**35** *(Vs)*	**40**	**43** *(Best Glide)*	**50** *(Approach)*	**60**	**65** *(Va)*	**70**	**80**	**83** *Vne*
kn IAS	**21**	**35**	**40**	**50**	**60**	**65**	**70**	**82**	**87**

5.4.5. A correction placard may now be fitted to the aircraft adjacent to the compass, similar to that shown in figure 4 below.

5.4.6. It is advisable to repeat the compass swing after all maintenance to, or addition of, electrical equipment.

6. Electrical Condition Gauges

6.1. Description. If a microlight is fitted with electrical systems, then an ammeter, voltmeter or battery charge warning light may occasionally be fitted according to the owners preferences.

6.2. Essential Requirements. All such indicators must be clearly placarded and protected by independent fuses if their failure could damage other aircraft systems (e.g. cause a battery drain), or cause overheating.

6.3. Advisable Requirements. It is recommended that tests are carried out using suitable test equipment to ensure that any such gauges are reading correctly and function as stated.

7. Switches

7.1. Description. Most microlights have toggle or key switches fitted in the cockpit. Their possible uses may include battery master, ignition, strobes, electric carburettor heater, and other electrical devices.

7.2. Essential Requirements.

7.2.1. All toggle switches must operate in the sense up=on, down=off. No other orientation is permitted. On a horizontal surface, “up” (“on”) is forwards.

7.2.2. All switches must be placarded showing their function and sense of operation.

7.2.3. It must be possible to look at any switch and see what state it is in (e.g. non-illuminating push-on, push-off switches are not permitted).

7.2.4. Ignition switches and wiring must comply with the requirements of TIL 007 and TIL 016.

7.2.5. Any emergency controls (e.g. an electrical fuel shut-off) must be coloured red.

7.2.6. Safety critical switches must be guarded or located so as to prevent inadvertent operation.

7.2.7. All switches must be rated for at least the current that they will be carrying.

7.3. Advisable Requirements.

7.3.1. Rubber boots which fit over toggle switches and protect them from water ingress can be obtained from chandlers and some microlight suppliers. Their use is recommended in open cockpits.

8. Fuel Pressure and Fuel Flow Gauges

8.1. Description. Various devices exist on the market which fit into the fuel line and measure fuel pressure and fuel flow. Fuel pressure is most commonly used, since some engine

Figure 4 , Example Compass Correction Card

For heading →	0	30	60	90	120	150	180	210	240	270	300	330
Steer →	0	25	58	90	125	160	190	215	240	270	305	332

suppliers may require it as a condition of warranty for most new engines. Fuel flow in itself is not particularly useful but will normally be connected to an electronic device which by integrating fuel flow with respect to time, can give an estimate of the fuel used (and thus fuel remaining).

8.2. Essential Requirements.

8.2.1. All connections must be secured, and all hose connections confirmed to be leak free.

8.2.2. After fitment of such a device (unless the modification is already approved by the aircraft manufacturer) a fuel flow test must be carried out. With the most common "Mikuni" fuel pumps, this is done by running the engine at maximum power and measuring the fuel bleed-off. Purely gravity fed systems must after passing through the device, and any in-line fuel filters still produce 150% of the maximum fuel flow, or for a pumped system, 125% of the maximum consumption of the engine. (A more detailed description of this process is given in TIL007.)

8.2.3. Fuel pressure measurement lines must meet all of the normal requirements for fuel lines, and be as short as possible.

8.2.4. Lines carrying fuel to sensors or gauges must have a restriction near to the gauge so that if the line comes away, there is not excessive fuel loss.

8.3. Advisable Requirements.

8.3.1. Fuel-flow based fuel level measurement systems should be calibrated, by comparing the actual fuel consumption on a long-ish flight with that indicated by the electronic system. If there are any significant errors observed, an aircraft fuel flow test should be carried out and a correction or warning placarded next to the indicator.

8.3.2. Where an additional restriction is imposed into a fuel line, it is suggested that a bypass hose and valve, operable from the cockpit, is available to allow the pilot to bypass this sensor or restriction if a fuel flow problem is suspected.

8.4. Use of the System. The following pointers relate to sensible use of these devices:

8.4.1. Unusually low fuel pressure readings may indicate any of a number of engine or fuel system faults. In such a case, the pilot should land as soon as is practicable. If necessary, safe fuel pressure may be briefly achieved by use of either an electric fuel pump or primer bulb if either is fitted.

8.4.2. Pilots should always maintain a regular cross-check between electronic fuel gauges and a sight tube or tank-dip.

9. Fuel Level Gauge

9.1. Description. There are several types of fuel level gauges which may be fitted to a microlight; many aircraft will have more than one type. Discussed here are the relative merits of each type and how to ensure that they are fitted safely.

9.2. Sight Gauges. (See figure 5)

9.2.1. Description. Sight gauges are transparent tubes which are level with the contents of the fuel tank. Alternatively, they may consist of markings on the side of a transparent fuel tank which are visible to the pilot. This is the most common system fitted to microlight aircraft and has the huge advantage of having very little to go wrong, although some microlight designers can be a bit optimistic about what can be seen when strapped into the pilot's seat.

9.2.2. Essential Requirements. The gauge must be in a position that can be seen by a pilot whilst strapped in, and of a material which is sufficiently clear that the fuel can be see through it. It may not be acceptable for this approach to be used with fibreglass tanks if they are not particularly clear. For tubes, some aircraft (such as the older Ravens) use a toughened glass tube, whilst others (such as the Sluka) use polyurethane tube; PVC tube is not permitted. Glass tubes should be adequately protected, usually with a surrounding PVC or polyurethane tube (PVC is permitted where it doesn't normally come into contact with fuel).

9.2.3. Desirable Requirements. A sight gauge should be calibrated. This is done by draining the tank of all but unusable fuel, then adding measured amount of fuel (typically 5 litres at a time). After each addition of fuel, the level is marked on the gauge in a position that can be seen by the pilot. If an aircraft is one in which passenger weight is permitted to be traded for fuel weight (see TIL026), then this calibration becomes essential. If the flight and ground attitudes are significantly different, it is prudent to calibrate in each attitude.

9.3. Mechanical Float Gauges.

9.3.1. Description. These are devices by which some gearing mechanism, or an upright rod, connects a float in the tank to an indicator, usually located on top of the tank. Although they were popular in older American light aircraft they are not often used in microlights, although some Pegasus and Mainair trikes have used variations upon this system.

9.3.2. Essential. The installation must be secure and leak free, with the gauge readily visible to the pilot. It must be confirmed that there is nothing around the float, inside the tank, which can cause it to snag and give incorrect readings. The float

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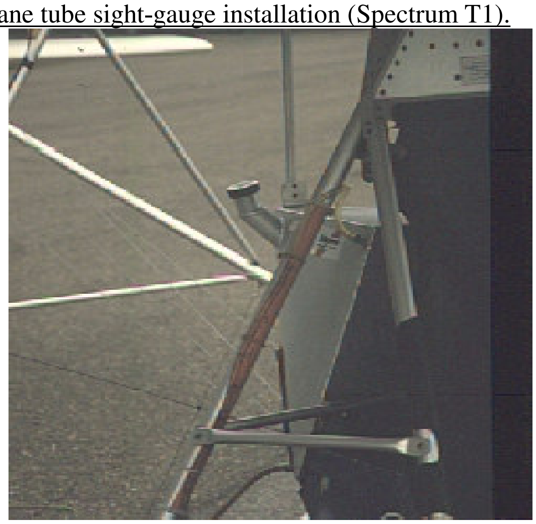
Figure 5 - Typical Polyurethane tube sight-gauge installation (Spectrum T1).



must be made of a material which will not be affected by continuous immersion in petrol.

9.3.3. Desirable. A calibration should be carried out, as described in 9.2.3 above.

9.4. Electronic Float Gauges.

9.4.1. Description. These work in a similar way to the mechanical float gauge, except that some form of electronic sensor measures the position of the float and displays the measurement on a gauge in the cockpit. Although not usually particularly precise (probably only having about 8 marked positions), they are very simple and reliable.

9.4.2. Essential. The installation must be secure and leak free, with the gauge readily visible to the pilot. It must be confirmed that there is nothing around the float, inside the tank, which can cause it to snag and give incorrect readings. The float must be made of a material which will not be affected by continuous immersion in petrol. If a reed-switch system is used, there must be nothing close to the fuel tank capable of creating a magnetic field strong enough to trigger them. If any wires pass into or through the fuel tank, they must not follow the same path at any point as any AC or DC power cable.

9.4.3. Desirable. A calibration should be carried out, as described in 9.2.3 above.

9.5. Capacitance Type Fuel Guages

9.5.1. Description. A capacitance type fuel gauge uses tiny electrical currents between two probes (or a probe inside a conductive tube) to measure the proportion of fuel to air within the tank. This is the type of system most commonly used on military aircraft and airliners.

9.5.2. Essential. The installation must be secure and leak free, with the gauge readily visible to the pilot. Nothing metallic must touch the probes. If any wires pass into or through the fuel tank, they must not follow the same path at any point as any AC or DC power cable.

9.5.3. Desirable. A calibration should be carried out, as described in 9.2.3 above. Some such systems have the facility to carry out a calibration which is then stored in the display unit, ensuring correct readings at all times.

9.5.4. Warning. This type of gauge has been known to read differently with different brands of petrol. For this reason, it is particularly important with capacitance gauges to regularly cross-check the cockpit gauge reading against a sight-gauge or dipstick. Also, wildly erroneous readings can be obtained if there is excessive water in the fuel.

10. Engine RPM Gauge

10.1. Description. An engine RPM gauge is a device which shows the operating engine speed. Generally it is connected to the engine's (AC) lighting circuit, and has internal mechanisms which determine the engine RPM from the AC frequency. Very few microlights now will not have an RPM gauge fitted, and it is the best indicator available of the engine power being generated (although they are notoriously inaccurate).

10.2. Essential.

10.2.1. The RPM gauge should be calibrated. The easiest way to do this is using an optical tachometer pointed at the propeller (many BMAA Inspectors own these, and they can also be purchased from model aircraft shops or from microlight engine suppliers), and plotting a graph of the engine RPM versus the indicated RPM. Don't forget to ensure that the optical tachometer is adjusted to the correct number of propeller blades, and that to obtain engine speed you multiply the propeller speed by the gearbox ratio. Placarded engine RPM limits must always reflect indicated values, not true RPM. If unsure of the accuracy of an optical tachometer, check it on a mains lightbulb, for a 2 blade propeller it should read 3000rpm, and for a 3 blade propeller, 2000rpm.

10.2.2. The RPM gauge, if running from the engine AC circuit, <u>must</u> be protected with a fuse or circuit breaker.

11. <u>Engine Temperature Gauges.</u>

11.1. <u>Description.</u> The engine temperature gauges usually are unpowered gauges based upon low current thermocouples. Because they are such sensitive instruments, they must be handled with care and not modified. The engine manual (and sometimes the TADS or HADS) will give advice about what combination of temperature gauges should be fitted to a particular aircraft.

11.2. <u>Essential.</u> The long cable which comes attached to the thermocouple must not be cut; if it is too long it should be loosely coiled. It is permissible if essential to fit an extension onto the end of the thermocouple cable, but this must be thick cored (low resistance) wire with identical lengths and joints on both sides of the circuit, otherwise the readings will be badly affected.

11.3. <u>Desirable.</u> If unsure about the quality of the thermocouple, place the end in a mug of boiling water, it should read 100°C / 212°F.

12. <u>Slip Ball</u>

12.1. <u>Description.</u> A slip ball is a device, working much like a spirit level, which gives a crude visual indication of whether the aircraft is flying in-balance or not. They are inexpensive devices normally stuck or screwed to the instrument panel in a 3-axis aircraft; they are not suited for use in weightshift aircraft.

12.2. <u>Essential Requirements.</u> The device must be secure and mounted as near as convenient to the centreline of the aircraft. It must be ensured that the slip ball is truly mounted parallel with the wings.

13. <u>Venturi Airspeed Indicators</u>

13.1. These are routinely fitted to trikes, using suction from a Venturi protruding through the side of the pod.

13.2. Although rarely particularly accurate, there is little to go wrong with these, and so long as they are securely fitted and pointed directly into the airflow, there is little which can be said about these. Ensure that all hoses are secure and free of leaks (this may not be easy, and often the only assurance is a thorough visual inspection).

14. <u>GPS, moving maps, radios and other electronic boxes.</u>

14.1. <u>Description.</u> This TIL will not attempt to describe how to use these devices, only how to install them without endangering the rest of the aircraft. Such devices are commonly fitted to microlights, in a variety of clamps, straps and mounts. The '100' series TILs deal with many of this sort of unit. Electronic condition gauges, ASIs, etc, can be used in place of their mechanical counterparts.

14.2. Essential Requirements.

14.2.1. The installation must be weighed, and using a spring balance shown to be secure when pushed to at least 9 times it's weight forwards, 4½ times its weight up and down, and 3 times it's weight to port and starboard.

14.2.2. The installation must not be permitted to obscure any primary flight instruments, or be in a position where it can obstruct emergency exit from the cockpit.

14.2.3. If connected to the aircraft's main power supply, the device must have a separate in-line fuse or circuit-breaker. If no fuse was supplied with the device, a rating of roughly 1.5 to 2 times the maximum current draw of the device is appropriate. If unsure of the current draw, use $current(amps) = \frac{power(watts)}{voltage}$.

14.2.4. Anything fitted with clamps, straps or velcro should also have a separate backup lanyard. At it's simplest, this is a piece of cord which is tied both to the device and a nearby bit of aircraft. The lanyard should be as short as possible and routed again so that it cannot snag anything in flight, or during an emergency exit.

14.3. Advisory Requirements.

14.3.1. If the aircraft radio runs from batteries, be aware of what can be switched off to prolong radio life, and what life may be expected.

14.3.2. LCD screens should be screened so that they remain readable in bright sunlight.

15. Finally - How to Approve Instrument Fits.

15.1. When to just get on with it. If instruments are being replaced simply to fit better, newer, or more reliable instruments than those fitted before in the same positions, a detailed airframe logbook entry must be made listing all of the instruments fitted and from where they were obtained, but no permission is required. BMAA Inspectors check the logbook at permit renewal, and will discuss any issues related to instrument replacements at that time. Similarly, there is no requirement to apply for any modification for the addition of standard, standalone gauges (not connected to other systems such as the aircraft's electrical or fuel systems) such as CHT, EGT, VSI, etc. so long as no huge changes are made to the instrument panel to fit them in, and the logbook entries are clear in describing what has been done.

15.2. When and how to apply for a modification. If anything is fitted to an aircraft which wasn't there before (e.g.. a large panel-mount moving map, or twice as many instruments as were originally fitted, or a new instrument panel), or any aircraft structure other than a non-structural instrument panel is going to be affected, then a modification application must be made to the BMAA. Similarly if anything is going to change the indicated flight limitations, this also requires a mod application. Swapping mechanical instruments for digital/electronic instruments should be done via a modification application, and we will need copies of the installation and operation instructions to help us understand how they work. If any of these are done, then the following needs to be sent to the BMAA Technical Office:

16. A completed form BMAA/AW/002
17. The appropriate application fee (as shown in the latest issue of Microlight Flying)

18. A list of all instruments and switches to be fitted. Instrument details should include the range and units of each instrument (e.g. ASI, knots, 0 - 90, 57mm diameter).
19. A drawing or photograph of the instrument panel as modified, to include fasteners/method of attachment to the airframe, materials and dimensions.
20. A diagram showing any wiring and/or plumbing being fitted to the aircraft.
21. Notes, signed by a BMAA Inspector or Technical Team member showing compliance with the requirements of this TIL, and any other published requirements applied to the instruments fitted.

21.1. <u>Homebuilts.</u> Standard instrument fits need not be specifically applied for to the BMAA, and can simply be overseen by the Inspector who will confirm using the information in this TIL that all is satisfactory. A list of *all* instruments fitted, with their ranges and units, should always be included in the stage inspections. If the Inspector feels that what is being done is sufficiently non-standard, then they should put together with the builder the information described in above (except for the form BMAA/AW/002 and fee, which are not required) and send it, referencing the homebuilt number to the BMAA Technical Officer. If it is considered necessary, the CTO will then issue an addendum to the next appropriate stage inspection providing the Inspector and builder with whatever additional checks are considered appropriate. Completed Standard Minor Mod forms (TIL ‘100’ series) should accompany the build paperwork for items such as radios, strobes, GPS units, etc.