BMAA TECHNICAL INFORMATION LEAFLET (TIL)

TIL 075 ISSUE 1

LIMITING SPEEDS, ASI CALIBRATION & MARKINGS

Contents

1. Introduction

By necessity, there is a difference between how an aircraft's limiting speeds are promulgated for BMAA amateur-built/kit aircraft compared to factory-built aircraft on the BMAA fleet. There is therefore the potential for confusion - particularly among pilots of amateur-built aircraft - about what speeds aircraft should be flown to, and the difference between calibrated and indicated airspeeds. This leaflet is intended to clarify matters for all.

This document (issue 1) is issued in September 2018. Comments or queries on this document should be emailed to technical.office@bmaa.org.

1.1. Summary - BMAA amateur-built aircraft

- The IAS limiting speeds for each individual aircraft are provided in that aircraft's approving MAAN (Microlight Airworthiness Approval Note). This is in the form of a placard that must be visible to the pilot (preferably adjacent to the ASI).
- It is wrong, and potentially dangerous, to use the CAS limiting speeds from the HADS or Flight Manual/POH.
- The ASI should also be marked - using the aircraft's individual IAS limiting speeds (not the CAS speeds) - as described in Section 5.
- If the aircraft's Pitot-static system is changed (or it is suspected that it might have changed) since the aircraft was originally built action is required. This is true even if the change is relatively subtle, such as a change in position of a Pitot tube or static port. Contact the Technical Office to discuss. At the very least the ASI calibration will need to be checked and the aircraft's approving MAAN updated as necessary.

1.2. Summary - factory-built aircraft on the BMAA fleet

- The IAS limiting speeds are provided in the TADS or Flight Manual/POH.
- The ASI should be marked as described in Section 5.
- Changes must not be made to the Pitot-static system on a factory-built aircraft. This invalidates the IAS limiting speeds, which are reliant on the Pitot-static system being completely standard. (In the unlikely event that a change is absolutely necessary, this must only be made with the approval of the BMAA Technical Office or type-approval holder.)

2. Airspeed definitions

2.1. Calibrated airspeed (CAS)

When an aircraft is designed, the limiting speeds - stall speed, maximum flap-extended speed, manoeuvring speed and never-exceed speed - are defined in terms of Calibrated Air-Speed (CAS).

If an airspeed indicating system - Pitot probe, static port, and instrument - were 100% accurate the Air-Speed Indicator (ASI) would display calibrated airspeed.

2.2. Indicated airspeed (IAS)

Indicated Air-Speed (IAS) is the airspeed actually displayed by the airspeed indicator (ASI).

This is generally different to calibrated airspeed due to errors in the measurement of Pitot pressure and static pressure, as well as instrument errors (inaccuracies in the airspeed indicator).

2.3. Limiting speeds

V_S Stalling speed

V_{S0} Stalling speed in landing configuration (flaps extended)

V_{S1} Stalling speed in cruise configuration (flaps retracted)

V_{FE} Maximum flaps extended speed

V_A Manoeuvring speed
The manoeuvring speed V_A is the maximum speed at which large / abrupt control inputs can be made without risk of immediate structural damage to the aircraft. For most Microlights - which do not have a maximum structural cruising speed V_{NO} defined - V_A should be used as V_{NO} and only exceeded in smooth conditions.

V_{NO} Maximum structural cruising speed
The maximum structural cruising speed V_{NO} is the maximum speed at which the aircraft can fly without risk of structural damage when flying through turbulence. V_{NO} should, therefore, only be exceeded in smooth conditions.

V_{NE} Never-exceed speed

3. Airspeed indicating system errors

An airspeed indicating system consists of a Pitot tube, a static port, an airspeed indicator, and tubing to connect them.

The Pitot tube is a tube pointing forward, which is designed to bring the air to rest (relative to the aircraft). The Pitot pressure of the airflow, increases as the aircraft flies faster.

The static port is a port - typically on the side of the aircraft, or on the side of a static probe (in the case of a combined Pitot-static head) - which is designed to measure the static pressure of the air. The static pressure is independent of the speed of the aircraft.

The airspeed indicator (ASI) is a pressure instrument that ‘calculates’ the airspeed from the difference between the Pitot and static pressures.

3.1. Pitot pressure errors

Pitot pressure errors tend to be small (as long as the Pitot tube is fairly well aligned with the airflow).

3.2. Static pressure errors (Position errors)

Static pressure errors normally dominate. It is very difficult to find a position on the aircraft where the airflow is not significantly disturbed by the aircraft. (For this reason, static pressure errors are also known as Position errors.)

3.3. Leaks

Leaks (or blockages) in the Pitot or static lines can introduce large errors.

Note that leaking Pitot or static lines is a defect that must be fixed. An ASI calibration is not intended to compensate for leaking Pitot or static lines.

3.4. Instrument errors

Although the instruments in Permit aircraft are not certified, they are usually reasonably accurate when new. Over time their accuracy can deteriorate though.

Note that if an ASI is found to have a significant instrument error it must be replaced. An ASI calibration is not intended to compensate for a deteriorating ASI.

4. Limiting speeds - amateur-built vs factory-built

When an aircraft is designed, the limiting speeds - stall speed, maximum flap-extended speed, manoeuvring speed and never-exceed speed - are defined in terms of calibrated airspeed (CAS). If, and it's a big IF, the airspeed indicating system on the aircraft was 100% accurate, the airspeed displayed to the pilot by the airspeed indicator - indicated airspeed (IAS) - would be exactly the same as CAS. Unfortunately, many of the airspeed indicating systems on Permit aircraft have significant errors: large enough that it makes no sense - and could be dangerous - for the pilot to fly using the CAS limiting speeds. Therefore, the aircraft manufacturer measures (as part of the aircraft's flight test programme) the airspeed indicating system errors, and works out IAS values for each of the CAS limiting speeds. These are then provided to the pilot to fly to.

The graph in Figure 1 shows the ASI errors from a Sky Ranger Nynja. The blue line shows that the airspeed indicating system under reads ever-so-slightly at low speed, and over reads a bit more significantly at high speed. (If there were no errors the blue line would lie on the orange dotted line.)

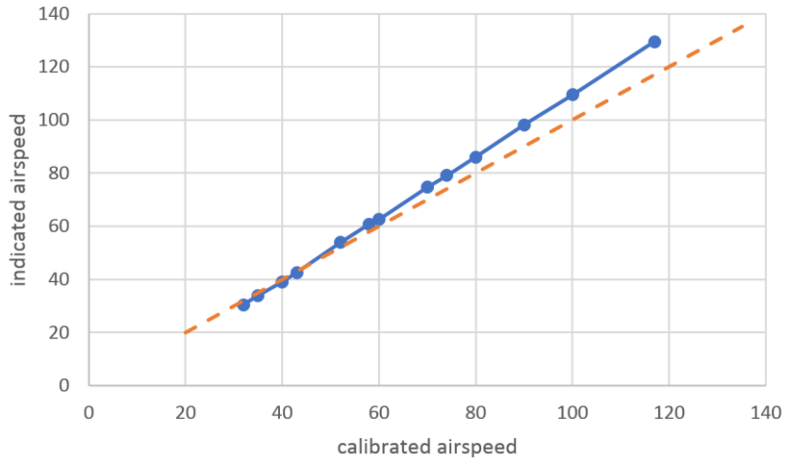

Figure 1: ASI errors for example Sky Ranger Nynja aircraft

Unfortunately, these errors are managed slightly differently for factory-built aircraft and amateur-built aircraft, which can lead to confusion.

4.1. Factory-built aircraft

For factory-built aircraft, the aircraft documentation - such as the Flight Manual (or Pilot's Operating Handbook) and TADS usually only list the IAS limiting speeds. They can do this because, being factory-built, all the examples of a type are essentially identical, and the difference in airspeed indicating system errors - from one aircraft to the next - will be small.

4.2. Amateur-built aircraft

Amateur-built aircraft are all slightly different, and there are often significant differences in the airspeed indicating system errors between different examples of nominally the same aircraft type. The test pilot therefore measures the errors, and the Technical Office generates a set of IAS limiting speeds, ***for each individual aircraft***. While this is great, it does mean that the generic documentation - such as the Flight Manual (or Pilot's Operating Handbook) and HADS - has to list the CAS limiting speeds. The IAS limiting speeds specific to each aircraft are provided in that aircraft's approving MAAN (Microlight Airworthiness Approval Note) in the form of a placard to be displayed next to the ASI on the instrument panel.

The placard for the Sky Ranger Nynja mentioned previously is shown in Figure 2. The CAS values in the top row are the 'design' limiting speed values, which are the same for all Nynjas, while the IAS values in the bottom row are corrected values taking into account the air speed indicating system errors measured when test flying this individual aircraft. While CAS values are conventionally presented in knots, IAS values are in the units of the ASI. Figure 2 assumes a knot ASI; if the aircraft had a mph ASI, the IAS values would be in mph, as shown in Figure 3.

knot CAS	32	35	40	43	52	58	60	70	74	80	90	100	117
(calibrated)	**V_{S0}**	**V_{S1}**		**min sink**	**glide / approach**	**climb**		**V_{FE}**	**V_A**				**V_{NE}**
knot IAS (indicated)	**30**	**34**	**39**	**43**	**54**	**61**	**63**	**75**	**79**	**86**	**98**	**109**	**129**

Figure 2: ASI calibration placard for example Sky Ranger Nynja (knot ASI)

knot CAS	32	35	40	43	52	58	60	70	74	80	90	100	117
(calibrated)	**V_{S0}**	**V_{S1}**		**min sink**	**glide / approach**	**climb**		**V_{FE}**	**V_A**				**V_{NE}**
mph IAS (indicated)	**35**	**39**	**45**	**49**	**62**	**70**	**72**	**86**	**91**	**99**	**113**	**126**	**149**

Figure 3: ASI calibration placard for example Sky Ranger Nynja (mph ASI)

The pilot of this aircraft must fly using the IAS values on the placard; the CAS values are included for information, and flight planning, purposes only. The (mph) ASI marked up for this aircraft is shown in Figure 4. The white arc - flap operating range - is from the landing configuration (flaps down) stall speed of 35 mph IAS (V_{S0}) to the flap limiting speed of 86 mph IAS (V_{FE}). The green arc - normal operating range - is from the cruise configuration (flaps up) stall speed of 39 mph IAS (V_{S1}) to the manoeuvring speed of 91 mph IAS (V_A). The yellow arc - caution range - is from the manoeuvring speed to the never-exceed speed of 149 mph IAS (V_{NE}). Speeds in excess of V_{NE} are marked with a red arc.

Figure 4: marked-up ASI for example Sky Ranger Nynja

4.3. Conclusion

In conclusion, whatever aircraft you fly make sure that you are using ***indicated***, or ***IAS***, limiting speeds. ***Calibrated***, or ***CAS***, limiting speeds are only useful for academic (and flight planning) purposes.

5. ASI markings

This section shows how the airspeed indicators on BMAA aircraft should be marked:

- The speeds used must be the indicated airspeeds (IAS) for the aircraft; using calibrated airspeeds (CAS) is wrong.
- V_{NE} can be identified using a red arc above V_{NE} as an alternative to the red marks shown below.
- V_{NO} is normally only defined for light aircraft (although some high-performance Microlight types also have a V_{NO}).
- The markings shown are the minimum required; some types may require additional markings (e.g. max flap speeds for different flap settings).

Note: marking of the ASI as described in this section only became a requirement in BCAR Section S issue 5, which was issued in November 2009. For aircraft approved before this date, it is still recommended to mark the ASI.

Microlight (no flaps)

Microlight (with flaps)

V_S	Stalling speed
V_{S0}	Stalling speed in landing configuration (flaps extended)
V_{S1}	Stalling speed in cruise configuration (flaps retracted)
V_{FE}	Maximum flaps extended speed
V_A	Manoeuvring speed
V_{NO}	Maximum structural cruising speed
V_{NE}	Never-exceed speed

Light aircraft

6. Airspeed Indicating System Calibration

6.1. Introduction

This section describes how to perform an airspeed indicating system calibration. Send the completed test card (Section 6.6.) to the BMAA Technical Office for processing.

An airspeed indicating system is calibrated by comparing the aircraft's indicated airspeed (what the ASI says) against the groundspeed (what a GPS says). By doing this into wind and downwind, and taking the average GPS groundspeed, the effect of wind is removed. (The effect of temperature and altitude is removed by the Technical Office when processing the results.)

6.2. Choosing a test altitude

The main requirement on a test altitude is that the air is smooth - and not too close to an altitude at which the air is turbulent. Note: the test altitude also needs to be safe from height, weather, traffic and airspace perspectives. Record what the test altitude is with 1013 hPa set on the altimeter. (If you fly the test with 1013 hPa set, remember to revert to QFE or QNH afterwards!)

6.3. Determining the wind direction

At your chosen test altitude, point the aircraft into your best guess at where the wind is coming from. Gently turn the aircraft until you find the heading at which the GPS groundspeed is a minimum. This is the actual into-wind heading. It's imperative to fly at a constant airspeed (and constant altitude) while doing this. The downwind heading is the reciprocal (± 180°) of the into-wind heading.

6.4. Performing the calibration

Fly the aircraft at a range of speeds from slow (stall speed plus a safety margin) to maximum straight and level speed in 10 mph/knot increments. For example, at 40, 50, 60, 70, 80 and 90 indicated on the ASI. (We need at least five calibration points; for slow aircraft it maybe necessary to use 5 mph/knot increments.)

At each speed fly the aircraft into wind and downwind recording the GPS groundspeed each time (while also attempting to maintain the chosen test altitude!). It is more efficient to fly all the into-wind legs first, then turn around and fly all the downwind legs. Note: you will cover much more ground flying downwind than into wind. Make sure you don't stray into airspace or get lost.

6.5. Safety

Flying an ASI calibration is not inherently hazardous. However, it takes concentration, which can mean that airmanship can get forgotten. Flying the aircraft safely remains the priority. It is worth considering taking an observer to record data, read the GPS while you fly the aircraft, and help maintain a lookout.

6.6. ASI calibration test card

Date:		**Airfield outside air temperature:**	°C
Aircraft registration:		**ASI units:**	(mph or knots)
Pilot:		**GPS (groundspeed) units:**	(mph or knots)
Flight test observer:		**Test altitude (1013 set):**	ft
Airfield:		**Into-wind heading:**	°
Airfield QFE:	hPa	**Downwind heading:**	°

indicated airspeed (ASI)	into-wind groundspeed (GPS)	downwind groundspeed (GPS)