AIRWORTHINESS BULLETIN

Calibration of Compasses

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1. Applicability

1.1 This Airworthiness Bulletin (AWB) is applicable to all aircraft and is intended to assist with calibrating and compensating aircraft magnetic compasses and provides data on the maximum allowable deviations enabling the compass to be maintained to its type design.

2. Purpose

2.1 The objective of this AWB is to establish the minimum standard of maintenance considered necessary to ensure the accuracy of an aircraft compass system.

2.2 This AWB provides information for the calibration of direct reading and remote reading magnetic compasses. Alternative standards may be used provided they can demonstrate an equivalent level of safety.

3. Background

3.1 The earth's magnetic field is a vector quantity and so requires three independent components to describe it in 3 dimensions. A common system of coordinates that is used to describe the earth's magnetic field is Declination (D), Inclination (I) and Total Intensity (F). The Declination is the angle the horizontal projection of magnetic field makes with true North (this is the direction of the compass needle); Inclination is the angle the magnetic field makes with horizontal plane; Total Intensity is the strength of the field. (See http://www.ga.gov.au/geomag/factsheets/earth_magfield_factsheet.jsp)

3.2 In Canberra ‘D’ is about 12.5 degrees East of North, ‘I’ is about 66 degrees directed out of the ground and ‘F’ is around 58200 nanoTeslas (nT). Resolving this into regular Cartesian coordinates where ‘X’ is true North component, ‘Y’ is East and ‘Z’ is vertical it is found that X=23100nT, Y=5100nT, Z=-53200nT approximately (‘Z’ is negative by convention in the Southern hemisphere and positive in the Northern hemisphere), i.e. there is much more vertical component than horizontal component. Inclination has the same algebraic sign as ‘Z’.

3.3 The Declination is sometimes called 'magnetic variation' and the Inclination is sometimes called the 'magnetic dip'. Because there is a vertical component of the earth's magnetic field (except at the magnetic equator) a compass needle will tend to tilt up or down as well as point to magnetic North. In the Southern (magnetic) hemisphere the North-seeking tip of a compass needle will tilt upward and in the Northern (magnetic) hemisphere will tend to dip down. In some compasses, particularly when used in high latitudes (towards the poles) this can cause the needle to touch the base-plate and result in bad readings. Some compasses and compass-theodolites do have a

mechanism to compensate for this effect. Any compensation would need adjustment for use at different magnetic latitudes (different Inclination or Dip). Others are constructed to be usable at all locations.

3.4 A Compass is initially verified at manufacture to ensure it meets the design standard and the indications are within the design tolerance. Compasses, once fitted to an aircraft, are calibrated in the aircraft on a compass swing site to allow for correction of the magnetic properties of the aircraft itself.

4. Definitions

Air Swing - means to conduct the inspection for the calibration of a compass during a flight detailed for this purpose.

Compensation - means the correction of deviations resulting from residual magnetism in an aircraft.

Calibration - means the measurement of the deviation of a compass installed in an aircraft, any necessary compensation of this deviation, and the recording of the residual deviation.

Deviation – means the angle required to be added algebraically to a compass reading to obtain the aircraft magnetic heading.

Direct Reading Compass - means a compass which has the magnetic sensing element and heading indication located in the one instrument.

Remote Indicating Compass (non-stabilised) - means a remote indicating compass without gyroscopic means of stabilisation or smoothing (e.g. magnesyn compass).

Remote Indicating Compass (stabilised) - means a compass which has the magnetic sensing element located remotely from the indicator(s) together with gyroscopic means of stabilise or smooth the heading indications.

Residual Deviation - residual deviation means the deviation remaining after compensation.

Standby Compass - means a direct reading compass which is not used as a primary heading reference.

5. Establishing a Compass Swing Site

5.1 Refer to CASA AC 139-15(0) dated February 2004.

6. When Should a Compass Calibration be Performed

6.1 Each installed compass should have a calibration check when the following events occur:

- Prior to the issue of a Certificate of Airworthiness (CofA).
- At least every 24 months when installed in an aircraft issued with an CofA, unless the approved maintenance programme prescribes a different period.
- Air transport aircraft, at the period prescribed in the operator's System of Maintenance.

6.2 Additionally each compass should also have a calibration check if an unusual event occurs such as:

- When a compass is initially installed or reinstalled in an aircraft.
- After an engine change, unless the manufacturer prescribes otherwise.
- Whenever a magnetic sensing element has been changed or relocated.
- After modification of an electrical or avionic installation in the aircraft, unless the certifying engineer is satisfied that the modification will not affect the compass.
- After a lightning strike, unless at least two heading checks 90º apart shows that no change of deviation has occurred.

  Note: A heading check may be made during the flight on which a strike has occurred if this procedure is documented in the appropriate aircraft manual. Refer to the section of this AWB dealing with lightning strikes and aircraft demagnetisation.

- After any maintenance involving the addition, removal, or relocation of magnetic materials likely to influence compass deviation.

  Note: Maintenance manuals may indicate the components that, if changed, would require the compass to be swung

- Following any operational occurrence, such as an accident, or heavy landing, that is likely to affect compass deviation.
- After long-term storage of the aircraft.
- Whenever there is reason to suspect that a change of deviation may have occurred.

7. Demagnetisation

7.1 Aircraft compass calibration can be affected by the magnetisation of the aircraft itself and the components fitted to the aircraft. This magnetisation may be a result of residual magnetism of the aircraft and components or as

result of a lightning strike. In the case of a lightning strike the disturbance can be very high and any demagnetisation should not be attempted until the aircraft is magnetically stable. Stabilisation may take several days.

7.2 A heading check may be sufficient during the flight on which a lightning strike has occurred if this procedure is detailed in the appropriate aircraft manuals. If a simple heading check is insufficient then the aircraft should be demagnetised in accordance with the manufacturer's recommendations.

7.3 After demagnetisation the aircraft should be flown twice, each flight for at least one hour, performing figure of eight manoeuvres on each of the cardinal compass headings to stabilise the magnetism. The deviations should be calculated during these flights to determine the effectiveness of the demagnetisation. The aircraft compass should be re-swung two months after the demagnetisation to ensure that the aircraft is magnetically stable.

8. Preparation

8.1 Prior to calibration the compass should be checked for the following:

- The serviceability of the compass should be checked and found to be in accordance with the manufacturer's specifications. In lieu of the manufacturer's specifications a direct-reading compass may be determined to be serviceable after taking into consideration the following:
    - there are no signs of leakage of the liquid;
    - bubbles, excessive sediment and discolouration is not present in the liquid;
    - the pivot friction does not exceed the compass manufacture's tolerance except where those tolerances are not known. The pivot friction should be determined by deflecting the compass through 10º then removing the deflecting force after which the compass should return to within 2º of its original indication; and
    - the compass mounting should be sound and serviceable.
- All equipment not normally carried in the aircraft should be removed.
- All equipment normally carried in the aircraft should be stored in its usual position.
- Engine(s) running;
- All doors closed;
- Flight controls as closely as practicable to cruise position; and
- Aircraft systems operating in the normal cruise configuration, including:
    - electrical systems,
    - navigation systems, and
    - communications.

Note: Direct reading compasses should be checked prior to installation to ensure that the compass element is balanced correctly.

8.2 Communications systems do not have to be transmitting or receiving during the calibration process.

9. General Swing Procedures

9.1 During compass calibration the aircraft should be positioned by aligning the fore and aft axis of the aircraft with the cardinal points and either every 30º or 45° magnetic headings (also known as a 12 point or 8 point compass swing) and should be no more than 5º from the required headings. The magnetic heading of the aircraft should be established by means of a landing compass or similar instrument, or by alignment with a marked compass site or known headings.

9.2 The flight controls should be operated and avionic systems switched on and off, or operated through the range permitted for cruising flight, to ascertain that there are no significant adverse affects. Calibration with engines inoperative may be possible if it can be demonstrated that there is no significant changes in deviation as with the engines running.

9.3 When calibrating in accordance with the above procedures, the residual deviation should not exceed.

- 2º for a remote indicating compass (stabilised);
- 5º for a remote indicating compass (non- stabilised);
- 5º for a direct reading compass used as the primary compass; and
- 10º for a standby compass.

9.4 Any practical combination of aircraft systems that are positioned, operated or loaded within their operating limits should not vary the compass deviations under the conditions specified above in excess of:

- 2º for a remote indicating compass (stabilised);
- 4º for a remote indicating compass (non- stabilised);
- 5º for a direct reading compass used as the primary compass; and
- 8º for a standby compass except that in specific circumstances, magnetic interference to a standby compass may exceed 8º provided that details of these circumstances are stated in the operations or flight manuals and placarded adjacent to the compass.

Note: An aircraft manufacturer may specify more stringent tolerances than those detailed above. In this case then the manufacturer's requirements take precedent

9.5 Magnetic interferences that occur occasionally and for short periods may be ignored.

10. Compass Compensation

10.1 Compasses should be compensated when the result of the compass calibration discloses:

- A deviation which differs by 3º or more from that anticipated by virtue of a previous calibration; or
- A deviation in excess of the limits specified in section 9.3 exists on any heading.

10.2 Compass compensation should be performed by aligning the fore and aft axis of the aircraft with each of the cardinal and 30º magnetic headings and:

- Determining compass deviations; and
- Compensating the compass for coefficients A. B. and C. if they exceed 2º; see section 11.5.

11. Procedures for Calibration and Compensation of Aircraft Compasses

CALIBRATION

11.1 Head the aircraft within 5º of each cardinal and 30º magnetic heading. Determine the deviation at each heading. At each cardinal heading check whether a change in deviation occurs when engine(s) electrical or radio equipment is operated. Repeat these checks at each 30º if a change in deviation does occur.

11.2 Compare the results of the calibration with the previous calibration

COMPENSATION

Note: Compensation may be made by either the correction of coefficients B and C or by halving the deviations of complementary cardinal headings. The latter method normally is only used for direct reading compasses in aircraft always operated in IFR conditions or for standby compasses.

COEFFICIENT METHOD

11.3 Set compensator magnets to neutral (where applicable).

11.4 Head the aircraft fore and aft axis within 5º of each magnetic cardinal heading and determine the deviations.

11.5 Calculate coefficients A, B and C by the formulae:

$$Coefficient\ A = \frac{Dev\ North + Dev\ East + Dev\ South + Dev\ West}{4}$$

$$Coefficient\ B = \frac{Dev\ East - Dev\ West}{2}$$

$$Coefficient\ C = \frac{Dev\ North - Dev\ South}{2}$$

11.6 With the aircraft on any cardinal magnetic heading add coefficient A algebraically to the compass reading to obtain the corrected heading. Rotate the compass or magnetic sensing element until the compass reads the corrected heading. This adjustment is not normally applicable to panel mounted compasses.

11.7 Head the aircraft on North within 5º. Add coefficient C algebraically to the compass reading. Adjust the NS compensator to make the compass read the corrected reading.

11.8 Head the aircraft on East within 5º. Add coefficient B algebraically to the compass reading. Adjust the EW compensator to make the compass read the corrected reading.

11.9 Repeat the compass calibration specified in paragraph 11.1 of this section.

SIMPLIFIED METHOD

11.10 Set the compensator magnets to neutral.

11.12 Determine and remove if applicable any coefficient A as specified in paragraph 11.4 and 11.5 of this section.

11.13 Head the aircraft on magnetic North within 5º. Determine the aircraft magnetic heading and adjust the NS compensator to make the compass read the aircraft magnetic heading.

11.14 Head the aircraft on magnetic East within 5º. Determine the aircraft magnetic heading and adjust the EW compensator to make the compass read the aircraft magnetic heading.

11.15 Head the aircraft on magnetic South within 5º. Determine the aircraft magnetic heading. Adjust the NS compensator to make the compass read half the difference between the aircraft magnetic heading and the compass reading.

11.16 Head the aircraft on magnetic West within 5º. Determine the aircraft magnetic heading. Adjust the EW compensator to make the compass read

half the difference between the aircraft magnetic heading and the compass reading.

11.17 Repeat the compass calibration specified in paragraph 11.1 of this section.

12. Air Swings

12.1 For aircraft equipped with inertial reference navigation systems an air swing may be conducted to ensure the serviceability of compasses. An air swing involves flying the aircraft on eight headings – north, north east, east, south east, south, south west, west, and north west – established from the inertial system and checking the aircraft magnetic compass heading against this heading. A flight test checklist should be used that provides for the pilot to record the directly read deviations. This checklist should be used to create the compass card and be included in the aircraft records.

12.2 For aircraft equipped with an Attitude and Heading Reference System (AHARS) an air swing may be conducted to ensure the serviceability of the magnetic compasses. An air swing involves flying the aircraft on eight headings – north, north east, east, south east, south, south west, west, and north west – established from the AHARS and checking the aircraft magnetic compass heading against this heading. A flight test checklist should be used that provides for the pilot to record the directly read deviations. This checklist should be used to create the compass card and be included in the aircraft records.

13. Recording

13.1 The results of each compass swing should be entered in the Aircraft Log Book or an approved alternative maintenance record, whichever is applicable.

13.2 A compass correction card should be compiled for primary and standby compasses in legible form showing:

- The magnetic heading and compass reading necessary to achieve the magnetic heading at the cardinal and intermediate 30º headings, unless the deviation under any condition of operation is less than one degree, in which case the card may be endorsed ‘ERRORS LESS THAN 1º’ in lieu of the corrected headings;
- The corrections to be applied where a change in compass deviation within the limits permitted in section 10 of this AWB is found during compass calibration due to the operation of radio or electrical services whose use may be optional depending on operational requirements;
- The date of the compass swing;
- The identification of the aircraft;

- The type and serial number of the compass; and
- The signature of the person appointed or authorised to certify for completion of the compass swing.
- The compass correction card should be provided with protection against water or other damage, and should be installed near the compass in easy view of the flight crew.

14. Enquiries

Enquiries with regard to the content of this Airworthiness Bulletin should be made via the direct link e-mail address: AirworthinessBulletin@casa.gov.au

Or in writing, to:

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