MIL-STD-765A
4 JANUARY 1967

Superseding
MIL-STD-765
3 April 1962

MILITARY STANDARD

COMPASS SWINGING, AIRCRAFT,

GENERAL REQUIREMENTS FOR

FSC 6605

DEPARTMENT OF DEFENSE
Washington, D. C. 20301

Compass Swinging, Aircraft, General Requirements for
MIL-STD-765A

1. This standard has been approved by the Department of Defense and is mandatory for use by the Departments of the Army, the Navy, and the Air Force, effective 4 January 1967.

2. Recommended corrections, additions, or deletions should be addressed to the Systems Engineering Group, Standardization Branch, Deputy for Systems Engineering, Attn: SEPS, Wright-Patterson AFB, Ohio 45433.

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COMPASS SWINGING, AIRCRAFT, GENERAL REQUIREMENTS FOR

1. SCOPE

1.1 Purpose. This standard provides general requirements governing the swinging of compasses in aircraft compensation and calibration. It pertains specifically to accurate swinging of compasses in all fighter, bomber, cargo, or helicopter type aircraft utilizing a standard magnetic compass.

1.2 Classification. Methods of swinging compasses outlined herein are as follows:

Method I - Ground swinging
Method II - Air swinging

2. REFERENCED DOCUMENTS

2.1 The issues of the following documents, in effect on date of invitation for bids, form a part of this standard to the extent specified herein:

SPECIFICATIONS

Military

MIL-C-7762	Compasses, Installation of
MIL-C-26524	Calibration Set, Magnetic Compass, Type MC-1

STANDARDS

Military

AN5823	Card-Compass Correction

PUBLICATIONS

Navy Department Oceanographic Office

H.O. 211	Dead Reckoning Altitude and Azimuth Table
H.O. 214	Tables of Computed Altitude and Azimuth
H.O. 218	Astronomical Navigation Tables

3. DEFINITIONS

(Not applicable)

4. GENERAL REQUIREMENTS

4.1 Method I - ground swinging. Compass swinging may be accomplished on the ground by any one of the six following procedures:

I(a) Compass rose
I(b) Sighting compass
I(c) Magnetic method, using transit
I(d) Transit method
I(e) Electrical method, using type MC-1 magnetic compass calibrator set
I(f) Comparison swinging

The aircraft communication and electrical systems shall be in operation during each of these entire procedures.

4.1.1 Method I(a) - compass rose procedure.

4.1.1.1 Compass swinging base. The compass swinging base (compass rose) shall consist of a level circular area, having a smooth surface of sufficient strength to support the weight of the aircraft without cracking or forming depressions under the wheels. No magnetic materials shall be used in the construction of the compass rose. The direction of the horizontal component of the earth's magnetic field, measured at any point within a space between 2 and 6 feet above the surface of the base, and extending over an area 250 feet in radius from the center of the base, shall not differ by more than 0.2 degree from the direction measured at any other point within this space. The direction and uniformity of the earth's field shall be determined by a licensed surveyor prior to the use of the area for compass swinging, and annually thereafter and also after any magnetic material, such as buildings, railroad tracks, direct-current power lines, etc., are installed within 200 yards of the rose. The date of observation and change in direction of the magnetic meridian, if any, shall be durably and legibly marked on the surface of the rose.

4.1.1.2 Means for aligning aircraft. The compass rose shall be provided with the following means for alignment of aircraft.

4.1.1.2.1 Radial lines for use with plumb bobs. The compass rose shall be provided with a series of 24 radial lines, either painted on or inlaid in the surface, extending toward magnetic directions every 15 degrees beginning with magnetic north. Each line shall be clearly labeled to indicate the direction along which it lies. The magnetic direction of each of the lines shall agree with the corresponding markings of the line within 1/2 degree. If any line is more than 1/2 degree off, it shall be relaid or repainted. Accuracy of direction of the radial lines shall be checked by a licensed surveyor. In addition to the radial lines, the compass rose shall be provided with two circular lines, either painted on or inlaid in the surface. One circular line shall have a radius of 50 feet and the other shall have a radius of 85 feet.

4.1.1.2.2 Radial bar for use as wheel chock. If this method is used, the compass rose shall be provided in addition to the radial lines, with a rigid nonmagnetic bar which pivots about the center of the rose and can be locked in each of 24 positions 15 degrees apart, including magnetic north. Each position of the bar shall be clearly marked in order to indicate the magnetic heading of an aircraft whose wheels rest against the bar. The surface of the bar against which the wheels of the aircraft are to rest shall be so beveled that a flat or approximately flat surface shall be exposed to the wheels. The magnetic direction of the bar in each position shall differ by

90 degrees from the corresponding marking of the rose within 1/2 degree. If any position of the bar is more than 1/2 degree off, the locked position shall be relocated.

4.1.1.3 Methods of aligning aircraft.

4.1.1.3.1 Compass rose with radial lines. Two plumb bobs shall be hung from points on the centerline of the aircraft, one near the nose, and the other near the tail. The aircraft shall be placed on the desired magnetic heading in such a way that the tips of the plumb bobs hang either directly over the appropriate line on the compass rose or on the same side of the line at equal perpendicular distances from it. The differences between the perpendicular distances of the tips of the bobs from the line shall not exceed 1/2 inch for each 15-foot separation of the bobs. If a wind is blowing, care shall be taken to shield the plumb bobs and their cords from the wind.

4.1.1.3.2 Compass rose with radial bar. If the radial bar-type of rose is used, the bar shall be locked in the desired position and the aircraft shall be aligned by pushing the wheels against the bar. Care shall be taken that both tires are correctly inflated, that both wheels actually touch the bar, and that neither wheel is pressed against the bar so tightly as to dent the tire. Landing gear alignment shall be checked by using plumb bobs as described above for alignment with the corresponding radial line in the first position. If any error in alignment is revealed, suitable allowance shall be made in all subsequent swing positions for that aircraft.

4.1.2 Method I(b) - sighting compass method.

4.1.2.1 Sighting compass. The sighting compass shall consist of a compass approved for this application to which has been attached a suitable sighting device. The sighting compass shall be calibrated by means of a compass test stand or other suitable apparatus in such manner that magnetic bearings taken with it will be accurate to the nearest 1/2 degree. The friction error shall not exceed 1 degree.

4.1.2.2 Check for local variations in magnetic field. The direction of the horizontal component of the magnetic field should be constant to within the tolerances specified in 4.1.1.1. The swinging area shall be checked annually for compliance with the above requirement by a licensed surveyor. In the event the area does not conform to the above requirement, the reason shall be determined and corrected or a new position located.

4.1.2.3 Method of determining magnetic heading of aircraft. The aircraft shall be placed in position on the swinging area. The sighting compass shall be placed in such position that a sight may be taken along a fore-and-aft reference line of the aircraft. In no fore-and-aft line is available, a lateral (athwartship) reference line shall be used. The sighting compass shall be at least 150 feet away from the aircraft, or far enough away to be undisturbed by any magnetic effects of the aircraft. Sights may be taken from in front of or behind, or from either side of the aircraft, depending on which provides the most accurate sight. Readings obtained from lateral sights shall be corrected by adding or subtracting 90 degrees, depending on the direction in which the sight is taken. Readings obtained by an observer standing (sighting) from in front of or behind the aircraft shall be corrected by adding or subtracting 180 degrees, depending on the direction from which sights are taken, unless the compass has been remagnetized to read directly the heading of the aircraft when sighting on it from the front.

4.1.3 Method I(c) - Magnetic method, using transit. An aircraft heading can be determined by means of surveyor's transit such as Eugene Dietzgen Company No. 6334C, or equivalent, to accuracies of 0.25 degree.

4.1.3.1 Practical requirements of precision ground swinging. The practical requirements of precision ground swinging of compass systems are as follows:

(a) A compass swinging area consisting of a smooth surface of sufficient size and strength to support the weight of the aircraft without cracking or forming depressions under the wheels, and to permit turning the aircraft through 360 degrees. The area must be free of all magnetic materials, and must be located away from power lines, buildings, and other aircraft in order that the direction of the earth's magnetic field is known and is constant throughout the area to within 0.2 of 1 degree.

(b) An object such as a radio antenna, water tower, or mountain peak which is visible through a transit from the selected area and which is not closer to the area than 6 "land miles".

(c) A surveyor's transit to facilitate accurate determination of the magnetic heading of the aircraft.

4.1.3.2 Transit location. The transit mounted on its tripod shall be so located that its optical axis is on the centerline (longitudinal axis) of the aircraft at least 150 feet in front of the aircraft. This position shall be of the same magnetic quality as that of the immediate vicinity of the aircraft, or the difference between the two shall be fixed and known.

4.1.3.2.1 From the fore end of the aircraft the surveyor shall sight two or more visible projections of the aircraft which have been determined from the aircraft manufacturer's drawings to be located on the longitudinal axis. These projections, i.e., antennae, rivet line, tail skid, nose wheel, etc., shall be located, one near the fore and the other near the aft end of the aircraft. (The vertical stabilizer cross hair of the transit shall be made to coincide with two projections on the longitudinal axis by moving the transit by trial and error until the desired condition exists when the transit bubbles indicate level.) The magnetic needle shall then be freed and allowed to come to rest. This needle can be read to 1/10 of 1 degree. In north latitude the pointer end with the balance weight is the south end of the needle. The magnetic heading is then determined from the reading of the south end of the pointer and the following formulae:

(a) If the south end of the pointer is in the northeast quadrant, the magnetic heading of the aircraft is the pointer reading.

(b) If the south end of the pointer is in the southeast quadrant, the magnetic heading of the aircraft is 180 degrees minus the pointer reading.

(c) If the south end of the pointer is in the southwest quadrant, the magnetic heading of the aircraft is the pointer reading plus 180 degrees.

(d) If the south end of the pointer is in the northwest quadrant, the magnetic heading of the aircraft is 360 degrees minus the pointer reading.

(1) If there exists a difference of magnetic quality between the position of the aircraft and that of the transit, this variation shall be applied to the magnetic heading as determined by the transit to obtain the actual magnetic heading of the aircraft. The formulae or definition for deviation is D=(CH) - (MH) or Deviation = Indicated Compass Heading (CH) minus Actual Heading of aircraft (MH). If the indicator compass heading is beyond or greater than the actual aircraft heading (MH) the deviation is plus (+). If the indicated compass heading is less or smaller than the actual aircraft heading (MH) the deviation is minus (-).

4.1.3.3 Alternate transit location. If it is impossible to align from the fore end of the aircraft, the aft end may be used. In this case, the north-seeking end of the pointer is read and the formulae are changed to read as follows:

(a) If the north end of the pointer is in the northeast quadrant, the magnetic heading of the aircraft is the pointer reading.

(b) If the north end of the pointer is in the southeast quadrant, the magnetic heading of the aircraft is 180 degree minus the pointer reading.

(c) If the north end of the pointer is in the southwest quadrant, the magnetic heading of the aircraft is the pointer reading plus 180 degrees.

(d) If the north end of the pointer is in the northwest quadrant, the magnetic heading of the aircraft is 360 degrees minus the pointer reading.

4.1.3.4 Transit mounting. The transit is then mounted rigidly on the aircraft with the "A" index set and locked on the outside azimuth scale at the number equivalent to the predetermined magnetic heading of the aircraft. The transit shall then be leveled, sighted on the distant object, and locked by means of the lower clamp screw and the lower clamp tangent screw. The aircraft may now be turned in azimuth and the magnetic heading of the aircraft determined on each heading by sighting on the distant object after leveling the transit and then reading the outside azimuth scale opposite the "A" index. This is accomplished by leveling the lower clamp screw locked through the use of the vernier plate clamp screw, and the vernier plate clamp tangent screw.

4.1.3.5 Time interval. On each new heading that is established for the aircraft (during the swinging procedure) the following methods shall be used to determine if the compass system is synchronized with the magnetic heading:

(a) If the aircraft is being swung without the engines operating, the synchronization of the system to the magnetic heading can be determined by observing the position of the sync needle. The heading of the compass system should be read five minutes after the sync position.

(b) If the aircraft is being swung with the engines operating, the synchronization of the system to the magnetic heading can be determined by the same method as that for the engines not operating, provided the sync needle does not oscillate more than 1/16 inch on both sides of the sync position. If the needle oscillates more than this amount the following procedure shall be used:

(1) If the sync needle hits one stop harder than the other or spends more time on one side of the sync position than the other, the system is not synchronized. When the needle appears to oscillate symmetrically about the sync position, the heading of the compass system should be observed and recorded, and after an elapsed time of 5 minutes the heading shall be recorded again. If this recorded heading differs from the previous recorded heading by more than 1/2 degree, at least 5 minutes more shall be allowed for the system to synchronize. This shall be repeated until the difference between the last recorded reading and the previous recorded reading does not exceed 1/2 degree. This reading can be assumed to be the magnetic heading of the compass system.

(c) If the compass system does not have a sync needle, a time interval of at least 5 minutes should be allowed to elapse before reading the magnetic heading.

4.1.3.6 Compass signal. In conducting this swing, the compass signal (electrical) is of prime importance when considering accurate swinging procedure or compensation. The visual indication of the compass system need not be of this accuracy and will, if necessary, utilize a compass correction card (see section 7).

4.1.4 Method I(d) - transit method. Transit method of heading determination on the sun (independent of magnetic influences) may be accomplished by the following procedure:

(a) Park plane on heading close to heading intended to fly.

(b) Turn tangant leveling screws equal and opposite directions for transit leveling.

(c) Line up transit on nose and rear radio antenna or tail-wheel hub.

(d) Continue moving, leveling, and sighting the transit until transit is level and aligned on fore-and-aft axes of aircraft.

(e) Loosen bottom plate or lower fast motion, and azimuth scale fast motion on the transit and set 180 degrees opposite lubber line of the inside scale.

(f) Lock the azimuth fast motion and adjust to exactly 180 degrees with azimuth slow motion.

(g) Resight on nose of aircraft with lower fast motion unlocked.

(h) Lock lower fast motion scales and make final sighting adjustment with lower slow motion.

(i) Do not touch either of the lower motion knobs hereafter. The instrument is in alignment with the fore-and-aft axes of the aircraft and pointed at aircraft.

(j) Loosen the azimuth fast motion and the telescope elevation fast motion.

(k) Make initial adjustment in such manner that the cross hairs of the scope appear tangent to the left edge of the sun and lock both fast motions. Place filter on telescope and adjust azimuth with azimuth slow motion.

(l) Read and record time and indicated relative bearing.

(m) Keep filter over end of telescope while on sun to prevent burning cross hair.

(n) With the cross hair appearing on the left edge of the sun in the field of the scope, subtract 0.25 degree from the relative bearing reading. When on the right side, add 0.25 degree to the indicated relative bearing reading.

(o) True heading may then be determined by computing true azimuth for the time of the observation and applying the formula TH=TA+RB.

4.1.5 Method I(e) - electrical method, using type MC-1 magnetic compass calibrator set. Any aircraft compass system utilizing a remote compass transmitter type C-2, C-3, DT-173/AJN, DT-198/AJN, or the electrical equivalent, can be swung electrically, using the type MC-1 magnetic compass calibrator set conforming to MIL-C-26524 without the necessity of rotating the aircraft.

4.1.5.1 Practical requirements of electrical swinging. The practical requirements of electrical swinging are:

(a) An area consisting of a smooth surface of sufficient size and strength to support the weight of the aircraft without cracking or forming depression. It should be such that the aircraft can be towed in and

aligned to magnetic north with as little trouble as possible. A straight-in approach is recommended. When the aircraft is parked on the north line, the area in a 10-foot radius circle beneath the transmitter location should have a uniform magnetic direction within 0.1 degree at a height of 5 feet.

(b) An object such as a radio antenna, water tower, or mountain peak which is visible with the naked eye from the selected area and which is not closer to the area than 1/2 "land mile."

(c) A magnetic compass calibrator set, type MC-1, or equivalent.

4.1.5.2 Procedure for electrical compass swinging. The procedures for electrical compass swinging using the magnetic compass calibrator set, type MC-1, or equivalent, are as follows:

(a) Set up the turntable over the spot where the remote compass transmitter will be located when the aircraft is positioned on the "north" line.

(b) Remove the remote compass transmitter from the aircraft and mount the transmitter on the turntable.

(c) Determine the alignment of the transmitter to magnetic north and its electrical calibration to the ambient magnetic field.

(d) Mount the necessary optical alignment equipment to the remote compass transmitter and align the telescope to some suitable target 1/2 mile or more away.

(e) Tow the aircraft into position on the north line and measure the displacement relative to the line per the plumb bob method specified in 4.1.1.3.1.

(f) Compute the optical alignment correction, insert into the optical alignment scope, and replace the compass transmitter in the aircraft sighting on the same target as used in 4.1.5.2(d).

(g) With the transmitter fastened down, reconnect the leads.

(h) Using the appropriate adapter cables, connect the compass calibrator set into the compass system. The aircraft magnetic headings are set in which the heading selector of the control console and the errors are recorded as the difference between the indicated heading and that set in with the heading selector.

4.1.6 Method I(f) - comparison swinging. Any aircraft which has had its remote compass system swung electrically by Method I(e), may have its standby compass swung against the calibrated system utilising any area sufficiently large to rotate the aircraft. Runways or taxiways may be utilised, provided the area is free from magnetic disturbances.

4.2 Method II - air swinging. Compass swinging may be accomplished in flight by either of the three following procedures:

II(a) Celestial bearings
II(b) Terrestrial bearings
II(c) Comparison bearings

4.2.1 Method II(a) - celestial bearings. Air swinging by celestial bearings may be accomplished by use of an astrocompass.

4.2.1.1 Astrocompass method. The mark II astrocompass shall be readable and accurate to within 1-1/2 degrees. The indirect sighting astrocompass, the precise astrocompass, and the periscopic sextant when used as a heading device shall be readable and accurate to 1/4 degree, or less. Mountings for the preceding instrument shall be installed in the aircraft with the fore-and-aft line of the mountings parallel to the fore-and-aft axis within 1/4 degree, or less.

4.2.1.1.1 Alignment of astrocompass mount in aircraft. The aircraft shall be placed on a known true heading on the ground, and the astrocompass shall be leveled and set on the sun or on a distant object whose true bearing is known. If the bearing, as found by the astrocompass, does not agree with the known bearing, the mounting shall be rotated by an amount sufficient to correct the error and reclamped.

4.2.1.1.2 Local hour angle (LHA) vs. Greenwich civil time (GCT).

4.2.1.1.2.1 Graph of LHA vs. GCT. The following procedure shall be carried out in advance before an air swing is made. A celestial body shall be chosen whose altitude will be less than 45 degrees during the time and at the place of the swing. With the aid of the air almanac or by other suitable methods, a graph shall be plotted of local hour angles against Greenwich civil time for the latitude and longitude of the point at which the center of the selected flying area and for the period of time during which the air swing is to be carried out. The flying area shall be a circular region of radius not exceeding 10 miles.

4.2.1.1.2.2 Method of aligning aircraft. The swings shall be carried out in smooth air. Visibility shall be such that the aircraft can be located with respect to the ground at all times. The aircraft shall be flown by automatic pilot or by reference to a directional gyro over the area previously selected while the sights are being taken. With the aircraft on the desired heading, the average reading of the compass for a 20- to 30-second period shall be estimated. At the same time, the astrocompass shall be read. The local hour angles set into the astrocompass shall be determined from the graph of local hour angles against Greenwich civil time in conjunction with a watch keeping Greenwich civil time. The true heading indicated by the astrocompass shall be converted to magnetic headings by applying the local variation, which may be taken from the latest local air map corrected for the date, or from any suitable source.

4.2.1.1.3 Azimuth vs. time.

4.2.1.1.3.1 Graph of azimuth vs. time. The following procedure shall be carried out in advance before an air swing is made. A celestial body shall be chosen whose altitude will be less than 45 degrees at the time and place of the swing. A graph shall

be plotted or a table constructed showing the azimuth of the selected celestial body against time at the center of the selected flying area for the period of time during which the air swing is to be carried out. The values of azimuth for a number of points on the graph or the values of azimuth contained in the table may be determined by the method of Navy Department Oceanographic Office publications H.O. No. 211, H.O. No. 214, or H.O. No. 218, the assumed position being the latitude and longitude of the center of the selected flying area, or by any other suitable accurate method. The flying area shall be a circular region of radius not exceeding 10 "land miles."

4.2.1.1.3.2 Method of aligning aircraft. Air swings shall be carried out in smooth air. Visibility shall be such that the aircraft can be located with respect to reference to a directional gyro over the area previously selected while sights are being taken. With the aircraft on the desired heading, the average reading of the compass for a 20- to 30-second period shall be estimated. At the same time, the astrocompass shall be read. The azimuth set into the astrocompass shall be determined from the graph for table of azimuth against time. The true headings indicated by the astrocompass shall be converted to magnetic headings by applying the local variation, which may be taken from the local air map corrected for the date, or from any other suitable source.

4.2.2 Method II(b) - terrestrial bearings.

4.2.2.1 Drift sight. A drift sight, a type which provides a reticle containing parallel grid lines, shall be used. The drift sight shall be installed in such a way that the grid lines are parallel to the fore-and-aft axis of the aircraft when the instrument is adjusted for zero drift.

4.2.2.1 Alignment of drift sight. A string shall be stretched under the drift sight parallel to the fore-and-aft axis of the aircraft. If the alignment is correct, the grid lines will be parallel to the string when the instrument is adjusted for zero drift. If the grid lines are not parallel to the string, the drift sight shall be realigned.

4.2.2.1.2 Method of aligning aircraft. Air swings shall be carried out in smooth air. Visibility shall be such that the landmark is not obscured by clouds or haze at any time during the swing. A suitable reference landmark shall be used such as a straight railroad, highway, or pipeline whose magnetic direction is known. The aircraft shall be flown by an automatic pilot or by reference to a directional gyro over the reference landmark and a line of the drift sight shall be aligned parallel to the landmark. The average of the compass readings for a 20- to 30-second period shall be estimated. The aircraft shall be on a straight level course during this time. The magnetic heading shall be determined by subtracting the bearing of the landmark relative to the aircraft from the magnetic direction of the landmark.

4.2.3 Method II(c) - comparison bearings. Air swings may be accomplished on compass systems which cannot be swung electrically, by comparing readings against those obtained from an electrically swung and compensated system.

4.3 Preliminary precautions. Prior to the swinging procedure, the following precatuions shall be observed.

4.3.1 Position magnetic equipment in aircraft. All magnetic equipment in the aircraft shall be secured in the position occupied in normal flight. All controls and levers shall be placed in their normal position.

4.3.2 Magnetic material carried by personnel. All observers who either read or are near the compasses during swinging shall possess no magnetic materials on their persons. These may include tools, pocket knives, mechanical pencils, metal wrist watch bracelets, eyeglasses with magnetic frames, officer's capes, badges, shop buttons, and head sets.

4.3.3 Nonmagnetic screwdriver. A nonmagnetic screwdriver shall be used for adjusting all magnetic compensators.

4.3.4 Other magnetic and nonmagnetic parts or equipment. Any jack, lift, hoist, or dolly which is used to lift the tail of the aircraft to a level flight position shall be made entirely of nonmagnetic material. If any magnetic parts are used, the apparatus shall be tested for its effect on the compass by being moved about the compass in a circle whose radius is equal to the normal distance between it and the compass. The changes in compass reading due to such movement shall not exceed 1/4 degree.

4.3.5 Removal of magnetic objects. Any magnetic objects, such as trucks, automobiles, railroad rolling stock, or other aircraft, shall be removed from the swinging area to a point at which they will have no magnetic effect on the compass.

4.3.6 Check for serviceability. Prior to swinging, the compass system shall be observed to be operating properly. Reference shall be made to the Compass System's Operation and Service Instruction Handbook or Technical Manual (T.O.) for detailed instructions on how to check for proper operation.

4.4 Swinging of production aircraft. Swinging of production aircraft shall be governed by the following considerations.

4.4.1 Difference of deviation between air swing and ground swing. If in the tests conducted in compliance with MIL-C-7762 on any one of the first few aircraft of any model, differences in deviation on any heading in excess of 2 degrees are found between the air swing and the ground swing performed with tail up and the engine running, a report of the differences shall be made to the procuring activity for the necessary action to be taken.

4.4.2 Difference of deviation due to attitudes. If the ground swing of any one of the first few aircraft of any model tested in compliance with MIL-C-7762, differences in deviation of 1 degree or more are found between the tail-up and tail-down positions of the aircraft on any one heading, a report of the differences shall be made to the procuring activity for the necessary action to be taken.

4.4.3 Difference of deviation due to equipment operation. If in the ground swing of any one of the first few aircraft of any model tested in compliance with MIL-C-7762, the operation of the engines or any electrical or other equipment which is normally operated in flight are observed to produce deviations of 1 degree or more in the compass, a report of the differences shall be made to the procuring activity for the necessary action to be taken.

4.5 Swinging of compasses having magnetic compensators. Detailed information concerning the following items shall be determined from the applicable manual concerning the specific compass being swung:

(a) The type compass transmitter, flux valve or detector, magnetic azimuth used

(b) The location of the B and C compensators, method of zero setting, and means of adjustment

(c) Additional types of compensators employed and method of adjustment

(d) Slaving rate of the system

(e) Swinging procedure details
(1) Ground swinging
(2) Air swinging

4.5.1 Ground swings. If engines are not running, the compass and remote compass transmitters, flux valve or detector, magnetic azimuth, shall be tapped lightly before reading.

4.5.1.1 Compass rose method. The aircraft shall be swung on a compass rose as follows.

4.5.1.1.1 The one cycle error which is caused by the magnetised components of the aircraft structure shall be removed or set to null effect by the proper adjustment to the magnet compensator which is mounted on the top of the detector.

4.5.1.1.2 The aircraft shall be placed on a south magnetic heading by the most suitable method and the compass reading noted, the compass deviation on the south heading shall be determined.

4.5.1.1.3 The aircraft shall be placed on a west magnetic heading and the compass reading noted. The deviation on the west heading shall be determined.

4.5.1.1.4 The aircraft shall be placed on a north magnetic heading and the compass reading noted. The deviation on the north heading shall be determined and the coefficient "C" computed. With the aircraft still on the north heading, the north-south compensator shall be adjusted as to cause the compass reading to change by an amount equal in magnetic and in algebraic sign to the coefficient "C". If the one cycle error compensator were removed in accordance with 4.5.1.1.1, the N-S compensator shall be adjusted on the North heading after the procedure of 4.5.1.1.5 has been completed. If the compensator is of the universal type, adjustment shall be made by turning the N-S compensator screw.

4.5.1.1.5 The aircraft shall be placed on an east magnetic heading and the compass reading noted. The deviation on the east heading shall be determined and the coefficient "B" computed. With the aircraft still on the east heading, the east-west compensator shall be so adjusted as to cause the compass reading to change by an

amount equal in magnitude and in algebraic sign to the coefficient "B". If the single cycle error compensator were removed in accordance with 4.5.1.1.1, the compensator shall be attached at this time and the East-West compensator shall be adjusted by the appropriate means. The airplane shall then be placed back on the North magnetic heading and the North-South compensator adjusted by the appropriate means. Magnetic compensators shall be adjusted by turning the E-W compensator screw.

4.5.1.1.6 While the aircraft is still on the east heading, the coefficient "A" shall be computed. Panel-mounted compasses shall be compensated for coefficient "A" if its magnitude exceeds 1 degree. Horizontal-mounted compass transmitters shall be compensated for coefficient "A" if its magnitude exceeds 1/2 degree. For panel-mounted compasses, compensation shall be accomplished by realigning the instrument panel or by turning the face of the compass relative to the plane of the instrument panel by means of washers or spacers. For magnetic compass transmitters, compensation of coefficient "A" shall be accomplished by loosening the mounting screws and rotating the transmitters by the required amount. Adjustment shall be such as to change the compass reading by an amount equal in magnitude and in algebraic sign to coefficient "A".

4.5.1.1.7 If the compass system has a transmission error compensator, the appropriate Handbook of Operation and Service Instructions or Technical Manual (T.O) shall be consulted on the method of making the compensation.

4.5.1.1.8 Swinging for calibration. After compensation, the aircraft shall be swung for residual deviations on the number of headings specified in the Operation and Service Instruction Handbook or Technical Manual (T.O.), and the compass readings recorded on a compass correction card. The correction card shall be mounted on the instrument panel near the compass or remote compass indicator.

4.5.1.2 Sighting compass method. Aircraft with compasses having magnetic compensators shall be swung with a sighting compass as follows.

4.5.1.2.1 The procedure described above for swinging compasses with magnetic compensators by the compass rose method shall apply, except that the alignment on the desired megnetic heading should be as follows:

(a) Five degrees for compass systems having only means to adjust for "A", "B", and "C" coefficients.

(b) One degree for compass systems having some type of deviation compensator in addition to the "A", "B", and "C".

4.5.1.2.2 Swinging for calibration. After compensation, the aircraft shall be swung for residual deviations on the number of headings specified in the Operation and Service Instruction Handbook, or Technical Manual (T.O.), approximately 45 degrees apart. The alignment shall be within 3 degrees on each heading. The compass reading, corresponding to the exact heading in each case, shall be recorded on the compass correction card, it being assumed that the deviation on the exact heading is the same as that on the actual approximate heading. For example, if the compass reading is 031 degrees on a magnetic heading of 029 degrees, the figure 032 should be entered on the card opposite a 30-degree heading.

4.5.2 Air swings. The aircraft shall be swung in the air as follows.

4.5.2.1 Setting to null effect. The compensator shall be set to null effect, as specified for swinging by the compass rose method (see 4.5.1.1.1).

4.5.2.1.1 The aircraft shall be flown successively on compass headings of approximately 090, 180, 270, and 000 degrees (within 5 degrees) and the corresponding magnetic headings shall be determined by any of the methods specified herein for air swings.

4.5.2.1.2 The aircraft shall be landed and coefficients "A", "B", and "C" shall be computed.

4.5.2.1.3 The aircraft shall be aligned on an approximately north magnetic heading and the compensator adjusted to compensate the coefficient "C", as described for the compass rose method (see 4.5.1.1.4). The alignment of the aircraft, which shall be within 5 degrees, may be accomplished either by means of a compass rose or sighting compass, or by reference to the aircraft's compass itself, after making due allowance for the magnetic deviation. It is assumed that the deviation on the ground is substantially the same as that in the air. For example, if the deviation on the north is +3 degrees, the compass reading on a north magnetic heading is 003 degrees. Therefore, the aircraft will be placed on a compass heading of approximately 003 degrees.

4.5.2.1.4 By one of the methods described above, the aircraft shall be aligned on an approximately east magnetic heading and the compensator adjusted to compensate the coefficient "B", as described for the compass rose method (see 4.5.1.1.5).

4.5.2.1.5 If necessary, as determined by the conditions stated under compass rose method (see 4.5.1.1.6), coefficient "A" shall be compensated.

4.5.2.1.6 Swinging for calibration. The aircraft shall be swung for residual deviations in the air on the number of headings specified in the Operation and Service Instruction Handbook or Technical Manual (T.O.), approximately 45 degrees apart. The corresponding magnetic headings shall be determined by any of the methods specified for air swings. The compass readings and deviations shall be entered on the compass correction card.

5. DETAIL REQUIREMENTS

(Not applicable)

6. EXAMPLES OF CALCULATING COEFFICIENTS

6.1 Compasses having magnetic compensators. Examples of calculating coefficients for compasses having magnetic compensators are as follows.

6.1.1 Compass rose method. It will be assumed that the compass to be swung is of the horizontal-mounted type.

6.1.1.1 Deviations with compensator set to null effect:

Magnetic heading	Compass reading	Deviation
180	175½	-4½
270	276	+6
000	006½	+6½
090	090	0

Coefficient "C": $C = \frac{1}{2}\left[+6\frac{1}{2} - (-4\frac{1}{2})\right] = \frac{1}{2}\ (+11) = +5\frac{1}{2}$ degrees.

With the aircraft on north magnetic heading (compass indication 006½ degrees), so adjust the N-S compensator that the compass will read 001 degree.

Coefficient "B": $B = \frac{1}{2}\left[0 - (+6)\right] = \frac{1}{2}\ (-6) = -3$ degrees.

With the aircraft on east magnetic heading (compass indication 090 degrees), so adjust E-W compensator that the compass will read 093 degrees.

Coefficient "A": $A = \frac{1}{4}\left[+6\frac{1}{2} + 0 + (-4\frac{1}{2} + (+6))\right] = \frac{1}{4}\ (+8) = +2$ degrees.

With the aircraft still on east magnetic heading, so realign compass that it will read 091 degrees.

6.1.2 Sighting compass method. It will be assumed again that the compass to be swung is of the horizontal-mounted type.

6.1.2.1 Deviations with compensator set to null effect:

Magnetic heading	Compass reading	Deviation
178	182	+4
271	267½	-3½
357	355	-2
086	089	+3

Coefficient "C": $C = \frac{1}{2}\left[-2 - (+4)\right] = \frac{1}{2}\ (-6) = -3$ degrees.

With the aircraft on a magnetic heading of 357 degrees (compass indicating 355 degrees), so adjust the N-S compensator that the compass will read 358 degrees.

Coefficient "B": $B = \frac{1}{2}\left[+3 - (-3\frac{1}{2})\right] = \frac{1}{2}\ (+6\frac{1}{2}) = +3\frac{1}{4}$ degrees.

With the aircraft on a magnetic heading of 086 degrees (compass indicating 089), so adjust the E-W compensator that the compass will read 086 degrees.

Coefficient "A": $A = \frac{1}{4}\left[-2 + (+3) + (+4)\right] + (-3\frac{1}{2}) = \frac{1}{4}\ (+1\frac{1}{2}) = +3/8$ degree.

Since coefficient "A" is less than one (disregarding algebrain sign), no compensation is necessary. If coefficient "A" is greater than one (again disregarding sign), the compass base should be rotated relative to the longitudinal axis of the aircraft by an amount and direction corresponding to the magnitude and algebraic sign of coefficient "A".

7. PROCEDURE FOR FILLING OUT STANDARD AN5823 COMPASS CORRECTION CARD

7.1 Explanation of procedure. The following section illustrates the procedure to be followed in filling out the compass correction card, conforming to AN5823, when an aircraft compass is swung and compensated. In the example herein it is assumed that the swinging compass is used to determine the magnetic headings of the aircraft. The steps to be taken are described in their proper sequence.

7.2 Procedure.

7.2.1 Recording of data. Suppose the indication of the swinging compass is 087 degrees and that of the aircraft compass 090 degrees. Enter the former in its proper space in the first column of the card labeled "Actual Head (M)" and the latter beside it in the second column labeled "Aircraft Comp." as shown below.

	Compensating Swing			Residual Swing	
	Actual Head (M)	Aircraft Comp.	Dev'n.	Actual Head (M)	Aircraft Comp.
N 000					
NE 045					
E 090	087	090			
SE 135					
S 180					
SW 225					
W 270					
NW 315					
	(1)	(2)	(2)-(1)	(3)	(4)

If swinging compass used ahead of aircraft, add or subtract 180 degrees

Coef C = $\frac{N-S}{2}$ = $\frac{(\ )-(\ )}{2}$ =

Coef B = $\frac{E-W}{2}$ = $\frac{(\ )-(\ )}{2}$ =

Coef A = $\frac{N+E+S+W}{4}$ = $\frac{(\ )+(\ )+(\ )+(\ )}{4}$ =

_____ Compass

Swung: _____ By: _____

To Fly	Steer	To Fly	Steer
N		180	
15		195	
30		210	
45		225	
60		240	
75		255	
90		270	
105		285	
120		300	
135		315	
150		330	
165		345	

Repeat this procedure on the other three cardinal headings, South, West, and North in that order. When the first two columns are completed, the card will then appear thus:

	Compensating swing			Residual swing		Compass Swung: ____ By: ____			
	Actual head (M)	Aircraft comp.	Dev'n.	Actual head (M)	Aircraft comp.	To fly N	Steer	To fly 180	Steer
N 000	005	001				15		195	
NE 045						30		210	
E 090	087	090				45		225	
SE 135						60		240	
S 180	176	180½				75		255	
SW 225						90		270	
W 270	265	273				105		285	
NW 315						120		300	
	(1)	(2)	(2)-(1)	(3)	(4)	135		315	
						150		330	
						165		345	

If swinging compass used ahead of aircraft, add or subtract 180 degrees

Coef C = $\frac{N-S}{2} = \frac{(\ )-(\ )}{2} =$

Coef B = $\frac{E-W}{2} = \frac{(\ )-(\ )}{2} =$

Coef A = $\frac{N+E+S+W}{4} = \frac{(\ )+(\ )+(\ )+(\ )+}{4} =$

7.2.2 Computations. Subtract compass reading of the aircraft (as read from the aircraft compass) from the magnetic heading of the aircraft. This difference and its sign are entered in the column titled "Aircraft Dev'n". At the bottom of this column, for reference purposes, is indicated the subtraction to be performed to obtain the entries, i.e., (column (1) minus column (2)). The step just described is illustrated in the next table.

	Compensating Swing			Residual Swing	
	Actual Head (M)	Aircraft Comp.	Dev'n.	Actual Head (M)	Aircraft Comp.
N 000	005	001	-4		
NE 045					
E 090	087	090	+3		
SE 135					
S 180	176	180½	+4½		
SW 225					
W 270	265	273	+8		
NW 315					
	(1)	(2)	(2)-(1)	(3)	(4)

If swinging compass used ahead of aircraft, add or subtract 180 degrees

Coef C = $\frac{N-S}{2} = \frac{(\ )-(\ )}{2} =$

Coef B = $\frac{E-W}{2} = \frac{(\ )-(\ )}{2} =$

Coef A = $\frac{N+E+S+W}{4} = \frac{(\ )+(\ )+(\ )+(\ )}{4} =$

Compass

Swung: _____ By: _____

To Fly	Steer	To Fly	Steer
N		180	
15		195	
30		210	
45		225	
60		240	
75		255	
90		270	
105		285	
120		300	
135		315	
150		330	
165		345	

Using these differences, calculate coefficients A, B, and C as shown in the next table. Note that all additions and subtraction are algebraic: that is, +(+) = +, -(-) = +, -(+) = -, +(-) = -.

	Compensating Swing			Residual Swing	
	Actual Head (M)	Aircraft Comp.	Dev'n.	Actual Head (M)	Aircraft Comp.
N 000	005	001	-4		
NE 045					
E 090	087	090	+3		
SE 135					
S 180	176	$180\frac{1}{2}$	$+4\frac{1}{2}$		
SW 225					
W 270	265	273	+8		
NW 315					
	(1)	(2)	(2)-(1)	(3)	(4)

If swinging compass used ahead of aircraft, add or subtract 180 degrees

Coef C = $\frac{N-S}{2} = \frac{(-4)-(+4\frac{1}{2})}{2} = -4\frac{1}{4}$

Coef B = $\frac{E-W}{2} = \frac{(+3)-(+8)}{2} = -2\frac{1}{2}$

Coef A = $\frac{N+E+S+W}{4} = \frac{(-4)+(+3)+(+4\frac{1}{2})+(+8)}{4} = +2\frac{7}{8}$

_____ Compass

Swung: _____ By: _____

To Fly	Steer	To Fly	Steer
N		180	
15		195	
30		210	
45		225	
60		240	
75		255	
90		270	
105		285	
120		300	
135		315	
150		330	
165		345	

7.2.3 Compensation. Compensate the compass as outlined in section 4, using the above coefficients. The compass must now be swung for residual errors. The residual errors result from other causes than those which give rise to coefficients A, B, and C. No provision is made to eliminate those causes of the residual errors. The card will appear as the next table after data from the residual swing is entered thereon.

	Compensating Swing			Residual Swing	
	Actual Head (M)	Aircraft Comp.	Dev'n.	Actual Head (M)	Aircraft Comp.
N 000	005	001	-4	002½	001
NE 045				040	043
E 090	087	090	+3	095	094
SE 135				136	134
S 180	176	180½	+4½	185	184
SW 225				222	225
W 270	265	273	+8	275	276
NW 315				317	316
	(1)	(2)	(2)-(1)	(3)	(4)

If swinging compass used ahead of aircraft, add or subtract 180 degrees

Coef C = $\frac{N-S}{2} = \frac{(-4)-(+4\frac{1}{2})}{2} = -4\frac{1}{4}$

Coef B = $\frac{E-W}{2} = \frac{(+3)-(+8)}{2} = -2\frac{1}{2}$

Coef A = $\frac{N+E+S+W}{4} = \frac{(-4)+(+3)+(+4\frac{1}{2})+(+8)}{4} = +2\frac{7}{8}$

Compass

Swung: _____ By: _____

To Fly	Steer	To Fly	Steer
N		180	
15		195	
30		210	
45	48	225	
60		240	
75		255	
90		270	
105		285	
120		300	
135	133	315	
150		330	
165		345	

The remaining blank column labeled "Steer," is filled in with data obtained from the residual swing. The entries for the "Steer" column, for any particular heading, is obtained by subtracting column 3 from column 4 and adding the result algebraically to the corresponding heading in the column labeled "To Fly." The following examples illustrate the method to be used. If the aircraft compass was observed to read 043 degrees while on an actual magnetic heading of 040 degrees during the residual swing, as indicated by columns 4 and 3, then the correction to be applied to the 45-degree heading in the compass card "To Fly" column will be given by subtracting 040 degrees from 043 degrees to arrive at a correction of +003 degrees. Adding this correction algebraically to the 45-degree heading under the "To Fly" column will result in a heading of 048 degrees to be entered opposite in the "Steer" column.

If the aircraft compass was observed to read 134 degrees while on an actual magnetic heading of 136 degrees during the residual swing as indicated by columns 4 and 3, then the correction to be applied to the 135-degree heading in the "To fly" column will be given by again subtracting column 3 from column 4 to arrive at a correction of (-2) degrees. Adding this correction algebraically to the 135-degree heading in the "To fly" column will result in a heading of 133 degrees to be entered opposite in the "Steer" column.

	Compensating swing			Residual swing		Compass Swung: By:			
	Actual head (M)	Aircraft comp.	Dev'n.	Actual head (M)	Aircraft comp.	To fly	Steer	To fly	Steer
						N	358½	180	179
N 000	005	001	-4	002½	001	15	15½	195	196
NE 045				040	043	30	32	210	212½
E 090	087	090	+3	095	094	45	48	225	228
SE 135				136	134	60	62	240	242½
S 180	176	180½	+4½	185	184	75	75½	255	257
SW 225				222	225	90	89	270	271
W 270	265	273	+8	275	276	105	103½	285	285½
NW 315				317	316	120	118	300	299½
	(1)	(2)	(2)-(1)	(3)	(4)	135	133	315	314
If swinging compass used ahead of aircraft, add or subtract 180 degrees						150	148	330	328½
						165	163½	345	343½

$$\text{Coef C} = \frac{N-S}{2} = \frac{(-4)-(+4\frac{1}{2})}{2} = -4\frac{1}{4}$$

$$\text{Coef B} = \frac{E-W}{2} = \frac{(+3)-(+8)}{2} = -2\frac{1}{2}$$

$$\text{Coef A} = \frac{N+E+S+W}{4} = \frac{(-4)+(+3)+(+4\frac{1}{2})+(+8)}{4} = +2\text{-}7/8$$

The columns labeled "To fly" and "Steer" indicate the course the pilot should "Steer" in order "To fly" a desired magnetic heading, or vice versa. For example: If the pilot wished "to fly" a magnetic heading of 045 degrees, he should "Steer" a heading of 048 degrees, or by the same token, if he is steering a heading of 133 degrees, then he is making a good magnetic heading of 135 degrees.

Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.

Custodians:
Army - MO
Navy - AS
Air Force - (11)

Reviewer activities:
Army - MO
Navy - AS, SH
Air Force - (11)

Preparing activity:
Air Force - (11)

Project No. 6605-0083

MIL-STD-765A
NOTICE 1
26 July 1978

MILITARY STANDARD
COMPASS SWINGING, AIRCRAFT, GENERAL REQUIREMENTS FOR

TO ALL HOLDERS OF MIL-STD-765A.

1. THE FOLLOWING PAGES OF MIL-STD-765A HAVE BEEN REVISED AND SUPERSEDE THE PAGES LISTED:

NEW PAGE	DATE	SUPERSEDED PAGE	DATE
ii		ii	4 January 1967
iii		iii	4 January 1967
iv		iv	4 January 1967
1		1	4 January 1967
2		2	4 January 1967
3		3	4 January 1967
4		4	4 January 1967
7		7	4 January 1967
8		8	4 January 1967
10		10	4 January 1967

2. THE FOLLOWING NEW PAGES ARE TO BE INSERTED AS LISTED:

NEW PAGE

v
vi
1a
2a
3a
4a
8a

3. RETAIN THIS NOTICE PAGE AND INSERT BEFORE THE TABLE OF CONTENTS.

4. Holders of MIL-STD-765A will verify that page changes and additions indicated above have been entered. The notice page will be retained as a check sheet. This issuance, together with appended pages, is a separate publication. Each notice is to be retained by stocking points until the Military Standard is completely revised or cancelled.

Custodians:
Army - AV
Navy - AS
Air Force - 11

Reviewer activities:
Army -
Navy -
Air Force - 99

Preparing activity:
Air Force - 11

(Project 6605-0260)

FSC 6605

DEPARTMENT OF DEFENSE
Washington, DC 20301

Compass Swinging, Aircraft, General Requirement For

MIL-STD-765A

1. This Military Standard is approved for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to the Aeronautical Systems Division, Attn: ASD/ENESS, Wright-Patterson Air Force Base, Ohio 45433, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

Supersedes page ii of 4 January 1967.

CONTENTS

Supersedes page iii of 4 January 1967.

CONTENTS (Continued)

Supersedes page iv of 4 January 1967

CONTENTS (Continued)

CONTENTS (Continued)

1. SCOPE

1.1 Purpose. This standard provides general requirements governing the swinging of compasses in aircraft compensation and calibration. It pertains specifically to accurate swinging of compasses in all fighter, bomber, cargo, or helicopter type aircraft utilizing a standard magnetic compass.

1.2 Classification. Methods of swinging compasses outlined herein are as follows:

Method I - Ground swinging

Method II - Air swinging

2. REFERENCED DOCUMENTS

2.1 Issues of documents. The issues of the following documents, in effect on date of invitation for bids, form a part of this standard to the extent specified herein:

SPECIFICATIONS

MILITARY

MIL-C-7762	Compasses, Installation Of
MIL-T-9145	Transmitter, Remote Compass, Bombing, Navigational Computer, Type C-3
MIL-T-19576	Transmitter, Remote Compass, Thin-Wing, Type ML-1 (Unstabilized)
MIL-T-25193	Transmitter, Remote Compass, Type C-2 (Unstabilized)
MIL-D-26503	Detector, Magnetic Azimuth, and Compensator, Detector, Magnetic Azimuth
MIL-C-26524	Calibrator Set, Magnetic Compass, Type A/E37T-10
MIL-D-38134	Detector, Magnetic Azimuth DSU-4/A, High Temperature

STANDARDS

MILITARY

AN5823	Card-Compass Correction

PUBLICATIONS

NAVAIR 17-15CAA-45 Calibrator Set, Magnetic Compass, Type MC-2

NAVY DEPARTMENT OCEANOGRAPHIC OFFICE

H.O. 211 Dead Reckoning Altitude and Azimuth Table

H.O. 214 Tables of Computed Altitude and Azimuth

H.O. 218 Astronomical Navigational Tables

(Copies of specifications, standards, drawings and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

3. DEFINITIONS (Not applicable)

4. GENERAL REQUIREMENTS

4.1 Method I - ground swinging. Compass swinging may be accomplished on the ground by any one of the six following procedures:

I(a) Compass rose

I(b) Sighting compass

I(c) Magnetic method, using transit

I(d) Transit method

I(e) Electrical method: Any aircraft compass system utilizing a remote transmitter, detector or calibrator set specified below may be swung electrically without the necessity of rotating the aircraft.

1. Type C-2 Remote Compass Transmitter conforming to MIL-T-25193.
2. Type C-3 Remote Compass Transmitter conforming to MIL-T-9145.
3. Type ML-1 Remote Compass Transmitter conforming to MIL-T-19576.
4. Type DT309/AJN, DT310/AJN Magnetic Azimuth Detector, CN1072/AJN Magnetic Azimuth Compensator conforming to MIL-D-26503.
5. Type DSU-4/A Magnetic Azimuth Detector conforming to MIL-D-38134.
6. Type DSU-4A/A Detector Magnetic Azimuth High Temperature conforming to Sperry Rand Corporation Part Number 4017288 or equal.
7. Type A/E37T-10 (Previous Type MC-1/MC-1 Modified) Magnetic Compass Calibrator Set conforming to MIL-C-26524.
8. Type MC-2 Calibrator Set conforming to Sperry Rand Corporation Part Number 259 2080-5 or equal.

NOTE: Other electrical calibration sets and detectors which have been Government approved may be used.

I(f) Comparison swinging

The aircraft communication and electrical systems shall be in operation during each of these entire procedures.

4.1.1 Method I(a) - compass rose procedure

4.1.1.1 Compass swinging base. The compass swinging base (compass rose) shall consist of a level circular area, having a smooth surface of sufficient strength to support the weight of the aircraft without cracking or forming depressions under the wheels. No magnetic materials shall be used in the construction of the compass rose. The direction of the horizontal component of the Earth's magnetic field (magnetic declination) measured at any point within a space between 2 and 6 feet above the surface of the compass rose, and extending over the required area of the compass rose, shall not differ by more than 0.2 degree from the direction measured at any other point within this area. The direction and uniformity of the Earth's field shall be determined by a licensed surveyor prior to the use of the area for compass swinging. The swinging area shall be checked annually thereafter for compliance with the above requirement and also after any magnetic material, such as buildings, railroad tracks, direct-current powerlines, etc., are installed within 200 yards of the swinging area. These periodic checks will be performed by a licensed surveyor or when use of certified compass calibrator equipment is permitted, a trained/qualified specialist may be specified as the operator.

The date of observation and the mean magnetic declination of the area, as determined from the survey, shall be durably and legibly marked on the surface of the rose. Copies of the survey with all declination readings shall be retained by the custodian of the compass rose for a minimum of 2 years. A copy of each annual survey shall be forwarded to the cognizant higher command as designated.

4.1.1.2 Means for aligning aircraft. The compass rose shall be provided with the following means for alignment of aircraft:

4.1.1.2.1 Radial lines for use with plumb bobs. The compass rose shall be provided with a series of 24 radial lines, either painted on or inlaid in the surface, extending toward magnetic directions every 15 degrees beginning with magnetic North. Each line shall be clearly labeled to indicate the direction along which it lies. The magnetic direction of each of the lines shall agree with the corresponding markings of the line within 1/2 degree. If any line is more than 1/2 degree off, it shall be relaid or repainted. Accuracy of direction of the radial lines shall be checked by a licensed surveyor or when use of certified compass calibrator equipment is permitted, a trained/qualified specialist may be specified as the operator. In addition to the radial lines, the compass rose shall be provided with two circular lines, either painted on or inlaid in the surface. One circular line shall have a radius of 50 feet and the other shall have a radius of 65 feet.

4.1.1.2.2 Radial bar for use as wheel chock. If this method is used, the compass rose shall be provided in addition to the radial lines, with a rigid non-magnetic bar which pivots about the center of the rose and can be locked in each of 24 positions 15 degrees apart, including magnetic North. Each position of the bar shall be clearly marked in order to indicate the magnetic heading of an aircraft whose wheels rest against the bar. The surface of the bar against which the wheels of the aircraft are to rest shall be so beveled that a flat or approximately flat surface shall be exposed to the wheels. The magnetic direction of the bar in each position shall differ by

90 ±1/2 degrees from the corresponding marking of the rose. If any position of the bar is more than 1/2 degree off, the locked position shall be relocated.

4.1.1.3 Methods of aligning aircraft.

4.1.1.3.1 Compass rose with radial lines. Two plumb bobs shall be hung from points on the centerline of the aircraft, one near the nose, and the other near the tail. The aircraft shall be placed on the desired magnetic heading in such a way that the tips of the plumb bobs hang either directly over the appropriate line on the compass rose or on the same side of the line at equal perpendicular distances from it. The differences between the perpendicular distances of the tips of the bobs from the line shall not exceed 1/2 inch for each 15-foot separation of the bobs. If a wind is blowing, care shall be taken to shield the plumb bobs and their cords from the wind.

4.1.1.3.2 Compass rose with radial bar. If the radial bar-type of rose is used, the bar shall be locked in the desired position and the aircraft shall be aligned by pushing the wheels against the bar. Care shall be taken that both tires are correctly inflated, that both wheels actually touch the bar, and that neither wheel is pressed against the bar so tightly as to dent the tire. Landing gear alignment shall be checked by using plumb bobs as described above for alignment with the corresponding radial line in the first position. If any error in alignment is revealed, suitable allowance shall be made in all subsequent swing positions for that aircraft.

4.1.2 Method I(b) - sighting compass method.

4.1.2.1 Sighting compass. The sighting compass shall consist of a compass approved for this application to which has been attached a suitable sighting device. The sighting compass shall be calibrated by means of a compass test stand or other suitable apparatus in such manner that magnetic bearings taken with it will be accurate to the nearest 1/2 degree. The friction error shall not exceed 1 degree.

4.1.2.2 Check for local variations in magnetic field. The direction of the horizontal component of the magnetic field should be constant to within the tolerances specified in 4.1.1.1. The direction and uniformity of the Earth's field shall be determined by a licensed surveyor prior to the use of the area for compass swinging. The swinging area shall be checked annually thereafter for compliance with the above requirement and also after any magnetic material, such as buildings, railroad tracks, direct-current powerlines, etc., are installed within 200 yards of the swinging area. These periodic checks will be performed by a licensed surveyor or when use of a certified compass calibrator equipment is permitted, a trained/qualified specialist may be specified as the operator. In the event the area does not conform to the above requirement, the reason shall be determined and corrected or a new position located.

4.1.2.3 Method of determining magnetic heading of aircraft. The aircraft shall be placed in position on the swinging area. The sighting compass shall be placed in such position that a sight may be taken along a fore-and-aft reference line of the aircraft. If no fore-and-aft line is available, a

lateral (athwartship) reference line shall be used. The sighting compass shall be at least 150 feet away from the aircraft, or far enough away to be undisturbed by any magnetic effects of the aircraft. Sights may be taken from in front of or behind, or from either side of the aircraft, depending on which provides the most accurate sight. Readings obtained from lateral sights shall be corrected by adding or subtracting 90 degrees, depending on the direction in which the sight is taken. Readings obtained by an observer standing in front of the aircraft shall be corrected by adding or subtracting 180 degrees, unless the compass has been remagnetized to read directly the heading of the aircraft when sighting on it from the front.

4.1.3 Method I(c) - Magnetic method, using transit. An aircraft heading can be determined by means of surveyor's transit such as Eugene Dietzgen Company No. 6334C, or equivalent, to accuracies of 0.25 degree.

4.1.3.1 Practical requirements of precision ground swinging. The practical requirements of precision ground swinging of compass systems are as follows:

a. A compass swinging area consisting of a smooth surface of sufficient size and strength to support the weight of the aircraft without cracking or forming depressions under the wheels, and to permit turning the aircraft through 360 degrees. The area must be free of all magnetic materials, and must be located away from power lines, buildings, and other aircraft in order that the direction of the Earth's magnetic field is known and is constant throughout the area to within 0.2 of 1 degree. The direction and uniformity of the Earth's field shall be determined by a licensed surveyor prior to the use of the area for compass swinging. The swinging area shall be checked annually thereafter for compliance with the above requirement and also after any magnetic material, such as buildings, railroad tracks, direct-current powerlines, etc., are installed within 200 yards of the swinging area. These periodic checks will be performed by a licensed surveyor or when use of a certified compass calibrator equipment is permitted, a trained/qualified specialist may be specified as the operator.

b. An object such as a radio antenna, water tower, or mountain peak which is visible through a transit from the selected area and which is not closer to the area than 6 land-miles.

c. A surveyor's transit to facilitate accurate determination of the magnetic heading of the aircraft.

4.1.3.2 Transit location. The transit mounted on its tripod shall be so located that its optical axis is on the centerline (longitudinal axis) of the aircraft at least 150 feet in front of the aircraft. This position shall be of the same magnetic quality as that of the immediate vicinity of the aircraft, or the difference between the two shall be fixed and known.

4.1.3.2.1 From the fore end of the aircraft the surveyor shall sight two or more visible projections of the aircraft which have been determined from the aircraft manufacturer's drawings, to be located on the longitudinal axis. These projections, i. e., antennae, rivet line, tail skid, nose wheel, etc., shall be located, one near the fore and the other near the aft end of the aircraft. (The vertical stabilizer cross hair of the transit shall be made to coincide with two projections on the longitudinal axis by moving the transit by trial and error until the desired condition exists when the transit bubbles indicate level.) The magnetic needle shall then be freed and allowed to come to rest.

This needle can be read to 1/10 of 1 degree. In north latitude the pointer end with the balance weight is the south end of the needle. The magnetic heading is then determined from the reading of the south end of the pointer and the following formulae.

a. If the south end of the pointer is in the northeast quadrant, the magnetic heading of the aircraft is the pointer reading.

b. If the south end of the pointer is in the southeast quadrant, the magnetic heading of the aircraft is 180 degrees minus the pointer reading.

d. Continue moving, leveling, and sighting the transit until transit is level and aligned on fore-and-aft axes of aircraft.

e. Loosen bottom plate or lower fast motion, and azimuth scale fast motion on the transit and set 180 degrees opposite lubber line of the inside scale.

f. Lock the azimuth fast motion and adjust to exactly 180 degrees with azimuth slow motion.

g. Resight on nose of aircraft with lower fast motion unlocked.

h. Lock lower fast motion scales and make final sighting adjustment with lower slow motion.

i. Do not touch either of the lower motion knobs hereafter. The instrument is in alignment with the fore-and-aft axes of the aircraft and pointed at aircraft.

j. Loosen the azimuth fast motion and the telescope elevation fast motion.

k. Make initial adjustment in such manner that the cross hairs of the scope appear tangent to the left edge of the Sun and lock both fast motions. Place filter on telescope and adjust azimuth with azimuth slow motion.

l. Read and record time and indicated relative bearing.

m. Keep filter over end of telescope while on Sun to prevent burning cross hair.

n. With the cross hair appearing on the left edge of the Sun in the field of the scope, subtract 0.25 degree from the relative bearing reading. When on the right side, add 0.25 degree to the indicated relative bearing reading.

o. True heading may then be determined by computing true azimuth for the time of the observation and applying the formula TH=TA+RB.

4.1.5 Method 1(e) electrical method. Any aircraft compass system utilizing the instruments specified in 4.1 or equal may be swung electrically, without the necessity of rotating the aircraft.

4.1.5.1 Practical requirements of electrical swinging. The practical requirements of electrical swinging are:

a. An area consisting of a smooth surface of sufficient size and strength to support the weight of the aircraft without cracking or forming depression. It should be such that the aircraft can be towed in and aligned to magnetic North with as little trouble as possible. A straight-in approach is recommended. The area

shall be magnetically surveyed and the magnetic North line marked in accordance with the appropriate operation and service instruction manual pertinent to the type of calibrator set being used; i. e., NAVAIR-17-15CAA-45, T.O. 5N3-3-7-1, et cetera.

b. An object such as a radio antenna, water tower, or mountain peak which is visible with the naked eye from the selected area and which is not closer to the area than 1/2 land mile.

c. A Type A/E37T-10 magnetic compass calibrator set conforming to MIL-C-26524 or Type MC-2 calibrator set conforming to Sperry Rand Corporation Part No. 259 2080-5, or equal, or approved equivalents.

4.1.5.2 Procedures for electrical compass swinging. The typical procedures for electrical compass swinging using a type A/E37T-10 magnetic compass calibrator set conforming to MIL-C-26524 or a Type MC-2 calibrator set conforming to Sperry Rand Corporation Part No. 259 2080-5, or equal, or approved equivalent are as follows. These procedures may be modified to conform to the special requirements as determined by the exact type of compass calibrator set being used.

a. Set up the turntable over the spot where the remote compass transmitter will be located when the aircraft is positioned on the north line.

b. Remove the remote compass transmitter from the aircraft and mount the transmitter on the turntable.

c. Determine the alignment of the transmitter to magnetic North and its electrical calibration to the ambient magnetic field.

d. Mount the necessary optical alignment equipment to the remote compass transmitter and align the telescope to some suitable target 1/2 mile or more away.

e. Tow the aircraft into position on the north line and measure the displacement relative to the line per the plumb bob method specified in 4.1.1.3.1.

f. Compute the optical alignment correction, insert into the optical alignment scope, and replace the compass transmitter in the aircraft sighting on the same target as used in 4.1.5.2(d).

g. With the transmitter fastened down, reconnect the leads.

h. Using the appropriate adapter cables, connect the compass calibrator set into the compass system. The aircraft magnetic headings are set in which the heading selector of the control console and the errors are recorded as the difference between the indicated heading and that set in with the heading selector.

4.1.6 Method I(f) - comparison swinging. Any aircraft which has had its remote compass system swung electrically by Method I(e), may have its standby compass swung against the calibrated system utilizing any area sufficiently large to rotate the aircraft. Runways or taxiways may be utilized, provided the area is free from magnetic disturbances.

be plotted or a table constructed showing the azimuth of the selected celestial body against the time at the center of the selected flying area for the period of time during which the air swing is to be carried out. The values of azimuth for a number of points on the graph or the values of azimuth contained in the table may be determined by the method of Navy Department Oceanographic Office publications H. O. No. 211, H. O. No. 214, or H. O. No. 218, the assumed position being the latitude and longitude of the center of the selected flying area, or by any other suitable accurate method. The flying area shall be a circular region of radius not exceeding 10 land miles.

4.2.1.1.3.2 Method of aligning aircraft. Air swings shall be carried out in smooth air. Visibility shall be such that the aircraft can be located with respect to reference to a directional gyro over the area previously selected while sights are being taken. With the aircraft on the desired heading, the average reading of the compass for a 20- to 30-second period shall be estimated. At the same time, the astrocompass shall be read. The azimuth set into the astrocompass shall be determined from the graph for table of azimuth against time. The true headings indicated by the astrocompass shall be converted to magnetic headings by applying the local variation, which may be taken from the local air map corrected for the date, or from any other suitable source.

4.2.2 Method II(b) - terrestrial bearings.

4.2.2.1 Drift sight. A drift sight, a type which provides a reticle containing parallel grid lines, shall be used. The drift sight shall be installed in such a way that the grid lines are parallel to the fore-and-aft axis of the aircraft when the instrument is adjusted for zero drift.

4.2.2.1.1 Alignment of drift sight. A string shall be stretched under the drift sight parallel to the fore-and-aft axis of the aircraft. If the alignment is correct, the grid lines will be parallel to the string when the instrument is adjusted for zero drift. If the grid lines are not parallel to the string, the drift sight shall be realigned.

4.2.2.1.2 Method of aligning aircraft. Air swings shall be carried out in smooth air. Visibility shall be such that the landmark is not obscured by clouds or haze at any time during the swing. A suitable reference landmark shall be used such as a straight railroad, highway, or pipeline whose magnetic direction is known. The aircraft shall be flown by an automatic pilot or by reference to a directional gyro over the reference landmark and a line of the drift sight shall be aligned parallel to the landmark. The average of the compass readings for a 20- to 30-second period shall be estimated. The aircraft shall be on a straight level course during this time. The magnetic heading shall be determined by subtracting the bearing of the landmark relative to the aircraft from the magnetic direction of the landmark.

4.2.3. Method II(c) - comparison bearings. Air swings may be accomplished on compass systems which cannot be swung electrically, by comparing readings against those obtained from an electrically swung and compensated system or against those obtained from an inertial navigation system.

4.3 Preliminary precautions. Prior to the swinging procedure, the following precautions shall be observed