

SAE Aerospace An SAE International Group	AEROSPACE STANDARD	SAE AS5604	REV. A
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		Superseding AS5604	
Compass; Magnetic, Pilot's Standby			

RATIONALE

This document has been determined to contain basic and stable technology which is not dynamic in nature.

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NOTICE

This document has been taken directly from U.S. Military Specification MIL-C-5604B, Amendment 3 and contains only minor editorial and format changes required to bring it into conformance with the publishing requirements of SAE technical standards. The initial release of this document is intended to replace MIL-C-5604B, Amendment 3. Any part numbers established by the original specification remain unchanged.

The original Military Specification was adopted as an SAE standard under the provisions of the SAE Technical Standards Board (TSB) Rules and Regulations (TSB 001) pertaining to accelerated adoption of government specifications and standards. TSB rules provide for (a) the publication of portions of unrevised government specifications and standards without consensus voting at the SAE Committee level, and (b) the use of the existing government specification or standard format.

Under Department of Defense policies and procedures, any qualification requirements and associated qualified products lists are mandatory for DOD contracts. Any requirement relating to qualified products lists (QPL's) has not been adopted by SAE and is not part of this SAE technical document.

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1. SCOPE:

1.1 This specification covers the design requirements and all performance requirements for procurement of 1 7/8 inch dial pilot's standby compasses as specified herein.

1.2 Classification:

Standby compasses shall be of the following types: (See paragraph 6.2)

<i>MS</i>	<i>Volts</i>	<i>No. Lamps</i>
17983-1	6	1
17983-2	28	1
17983-3	6	2
17983-4	28	2

2. APPLICABLE DOCUMENTS:

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

SPECIFICATIONS

FEDERAL

QQ-C-320	Chromium Plating (Electrodeposited)
QQ-N-290	Nickel Plating (Electrodeposited)
QQ-P-416	Plating, Cadmium (Electrodeposited)
QQ-Z-325	Zinc Plating (Electrodeposited)

MILITARY

MIL-P-116	Preservation - Packaging, Methods of
MIL-D-1000	Drawings, Engineering and Associated Lists
MIL-L-5020	Liquid, Compass, Aircraft
MIL-E-5272	Environmental Testing, Aeronautical and Associated Equipment, General Specification for
MIL-C-5541	Chemical Conversion Coatings on Aluminum and Aluminum Alloys
MIL-S-6872	Soldering Process, General Specification for
MIL-S-7742	Screw Threads; Standard, Optimum Selected Series: General Specification for
MIL-A-8625	Anodic Coatings, for Aluminum and Aluminum Alloys
MIL-C-25050	Colors, Aeronautical Lights and Lighting Equipment, General Requirements for
MIL-L-25142	Luminescent Material, Fluorescent

2.1 (Continued):

STANDARDS

FEDERAL

FED-STD-1 Standard for Laboratory Atmospheric Conditions for Testing
FED-STD-595 Colors

MILITARY

MIL-STD-130 Identification Marking of U.S. Military Property
MIL-STD-143 Specifications and Standards; Order of Precedence for the Selection of
MIL-STD-794 Parts and Equipment Procedures for Packaging and Packing of
MIL-STD-889 Dissimilar Metals
MS25237 Lamp, Incandescent, Single Compact Midget Flanged Base (T 1 - 3/4 Bulb)
MS33558 Numerals and Letters, Aircraft Instrument Dial, Standard Form of
MS33586 Metals - Definition of Dissimilar
MS17983 Compass; Magnetic, Pilot's Standby

DRAWINGS

AIR FORCE-NAVY AERONAUTICAL STANDARD DRAWINGS

AN3116 Plug Assembly - Instrument Electrical

(Copies of the 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. REQUIREMENTS:

3.1 First Article:

When specified (see 6.2), the contractor shall furnish sample unit(s) for first article inspection and approval (see 4.3.1 and 6.2).

3.2 Selection of Government documents:

Specifications and standards for necessary commodities and services not specified herein shall be selected in accordance with Standard MIL-STD-143, except as provided in 3.2.1 and 3.2.2.

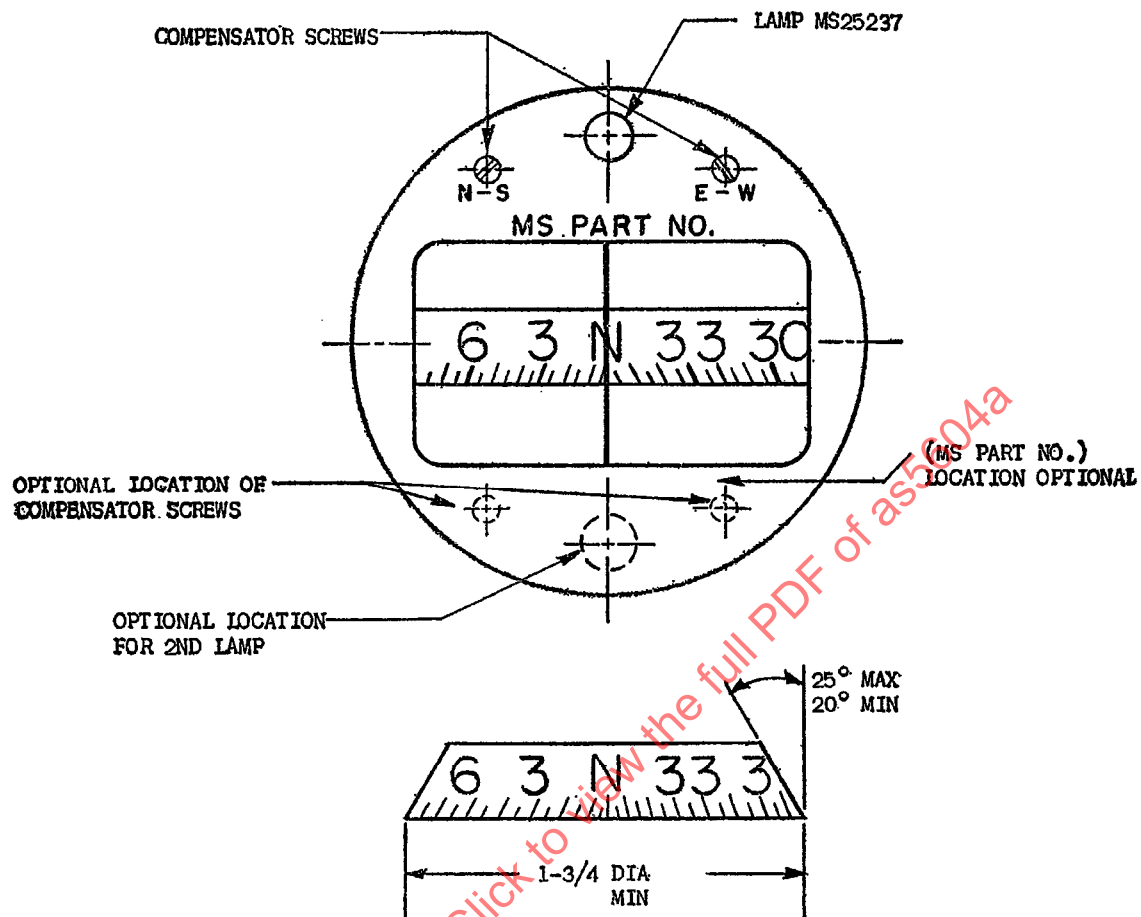
- 3.2.1 Commercial parts: Commercial parts having suitable properties may be used where, on the date of invitation for bids, there are no suitable standard parts. In any case, commercial utility parts, such as screws, bolts, nuts, cotter pins, having suitable properties may be used provided:
- (a) they can be replaced by the standard parts (MS or AN) without alteration.
 - (b) the corresponding standard part numbers are referenced in the parts list and, if practicable, on the contractor's drawings.
- 3.2.2 Standard parts: With the exception of 3.2.1, MS and AN standard parts shall be used where they suit the purpose. They shall be identified on the drawings by their part numbers.
- 3.3 Materials:
- Materials shall conform to applicable specifications and shall be as specified herein. Materials for which there are no applicable specifications, or which are not specifically described herein, shall be of the best quality, of the lightest practicable weight, and suitable for the purpose intended. The use of reclaimed materials in the manufacturing of the compass shall be encouraged to the maximum extent possible.
- 3.3.1 Critical materials: Noncritical materials shall be used where practicable. Where the use of a critical material is essential to meet specification requirements, the material used shall be the least critical of those which are adequate for the purpose.
- 3.3.2 Metals: Metals shall be of the corrosion-resistant type, or shall be suitably protected as specified herein to resist corrosion due to salt spray or atmospheric conditions to which the compass may be subjected when in storage or during normal service life.
- 3.3.2.1 Dissimilar metals: Unless suitably protected against electrolytic corrosion, dissimilar metals as defined in Standard MIL-STD-889 shall not be used in intimate contact with each other.
- 3.3.3 Nonmagnetic materials: Nonmagnetic materials shall be used for all parts of the compass except where magnetic materials are essential.
- 3.3.4 Fungus-proof materials: Materials which are nutrients for fungi shall not be used where it is practicable to avoid them. Where used and not hermetically sealed they shall be treated with a fungicidal agent acceptable to the procuring activity. However, if they will be used in a hermetically sealed enclosure, fungicidal treatment will not be necessary.
- 3.3.5 Corrosive fumes: The materials as installed in the compass and under the service conditions specified herein shall not liberate deleterious fumes.

3.4 Design and construction:

The outline dimensions of the compass shall conform to Standard MS17983. The compass shall be designed to incorporate a 28 or 6-volt lighting system using one or two lamps. The design of the compass shall be reasonably simple to permit overhaul or repair with a minimum of special tools and fixtures. The compass shall be constructed to withstand the normal strains, jars, vibrations, and such other conditions as are incident to shipping, storage, installation, and service.

- 3.4.1 Maintenance: The design of the compass shall be such as to facilitate to the greatest possible extent disassembly, reassembly, and service maintenance by those tools and items of maintenance equipment which are normally available as commercial standards.
- 3.4.2 Cover glass: The cover glass shall be of the flat type. It shall be clear and free from flaws which would affect the legibility of the card markings when the compass is filled with liquid and observed under normal operating conditions. The size of the cover glass shall be such that not less than 60 degrees of the card graduations are exposed for observation during normal use of the compass. The glass shall be thoroughly annealed.
- 3.4.3 Bowl: The bowl shall be made of low-density metal, shall be uniform in texture, shall have a smooth surface, and shall be of one-piece construction. Other types of construction will be permitted if acceptable to the activity responsible for qualification.
 - 3.4.3.1 Mounting flange: The mounting flange shall form an integral part of the compass.
 - 3.4.3.2 Expansion unit: The bowl shall incorporate a suitable expansion unit to permit the liquid to contract or expand as a result of temperature and altitude changes.
 - 3.4.3.3 Filler cap: The bowl shall incorporate a suitable filler cap so placed that the compass may be easily filled with liquid.
 - 3.4.3.4 Gaskets: Gaskets shall be made of material suitable for holding the damping liquid within the bowl. Sealing agents shall be of such nature that they will not contaminate the liquid.
 - 3.4.3.5 Jewel: The cup jewel shall be made of sapphire, free from surface flaws, and shall be a "snug fit" in the jewel retainer. Other material for the jewel may be used if acceptable to the activity responsible for qualification.
- 3.4.4 Lubber's line: The lubber's line shall be made of phosphor bronze or brass so constructed that parallax, when reading the card, will be reduced to a minimum. A plane through the pivot and the lubber's line shall form right angles with the plane of the mounting surface within the limits allowed in paragraph headed "Compass error without compensation."

- 3.4.5 Magnets: The compensating and card magnets shall be made of suitable magnetic material, shall be suitably heat-treated, magnetized to saturation, and aged to insure optimum performance.
- 3.4.6 Card assembly: The card assembly shall be as light in weight as practicable and sufficiently rigid to withstand service usage, and shall be spring mounted to absorb the external vibrations encountered in service. Precaution shall be exercised in soldering to prevent heating of the magnet.
- 3.4.6.1 Card: The card shall be constructed of aluminum, aluminum alloy, or other non-magnetic material, and shall be graduated at 5-degree divisions to represent horizontal angles as shown by Figure 1, within an accuracy of one degree.
- 3.4.6.2 Card pivot: The card pivot shall be constructed of high-grade steel or other suitable alloy properly hardened and polished on its working surface.
- 3.4.7 Compensating system: The compensating system shall consist of permanent bar magnets and shall consist of manually adjustable magnetic systems for removing the compass deviations on N-S (North-South) and E-W (East-West) headings. Both systems shall be provided with a zero index mark to show, when the system is in operation, where it exerts zero effect on the indication. The design of the systems shall be such that the zero index mark will read zero only when the system is in its zero effect position.
- 3.4.7.1 Adjustment of compensator: Adjustment shall be accomplished from the front of the compass. Each system shall be provided with a screw-type adjustment suitable for operation with a screwdriver. The compensator gearing shall be such that the change in compensation for equal angular displacements of the adjusting screws shall be the same for both N-S and E-W systems. It shall be possible to turn either adjustment continuously in one direction without meeting a stop, the compensation resulting from this treatment passing through complete cycles repeatedly. The compensator systems shall have sufficient friction in their operation to prevent changes in adjustment caused by vibration encountered in service. With compass heading north, a slight turn of the N-S compensator screw, off the zero position, shall change the reading of the compass card. With the compass heading east, a slight turn of the E-W compensator screw off the zero position shall change the reading of the compass card.
- 3.4.7.2 Cover plate: A cover plate shall be provided to cover the compensator-adjusting screws. The cover-plate-attaching parts shall be an integral part of the plate.
- 3.4.8 Lighting system: The compass shall be provided with a lighting system designed to receive a 6-volt or 28-volt power supply in the electrical connector socket. The lighting system shall be so designed that there will be no difference in the operation of the instrument with or without the lamp burning.



DIMENSIONS IN INCHES.

MARKING	HEIGHT OR LENGTH ±.010	WIDTH OF LINE ±.005	MATERIAL OR FINISH
NUMERALS 3, 6, 12, 15, 21, 24, 30, AND 33	.187	--	FLUORESCENT LUMINESCENT OR LUSTERLESS WHITE
30-DEGREE GRADUATIONS	.094	.031	
10-DEGREE GRADUATIONS	.094	.016	
CARDINAL POINTS N.E.S.W.	.187	--	
LUBBER'S LINE (APPROX)	.750	.016	
5-DEGREE GRADUATIONS	.062	.016	
(MS PART NO.)	.062	--	DURABLE BLACK

FIGURE 1. Face and Card Detail

- 3.4.8.1 Lamp: The lamps shall conform to Standard MS25237 and shall be located substantially as shown on Figure 1. The lamp shall be replaceable in flight without the use of tools. The color shall conform to the requirements of Specification MIL-C-25050 and shall be as specified by the procuring activity (see 6.2).
- 3.4.8.2 Lamp socket: The lamp socket shall be designed to accommodate a lamp conforming to Drawing MS25237. The lamp socket shall be so designed that clearance and satisfactory performance of the lamp is maintained with the lamp sleeve. Construction of the lamp socket shall be such that power is supplied to the lamp base and contact shoulder of the lamp.
- 3.4.8.3 Electrical connector socket: The compass shall incorporate an electrical connector socket equivalent to the arrangement shown on Figure 2, and suitable for attachment to the plug assembly shown by Drawing AN3116. A suitable cap shall be provided to protect contacts during shipment and storage.
- 3.4.8.4 Wiring circuit: The wiring circuit between the lamp socket and connector socket shall be a twisted two-conductor system, insulated from the compass case and suitably shielded to eliminate radio interference.
- 3.4.8.5 Brightness: With the compass so mounted that the cover glass is vertical, the light source or lamp illuminating the compass shall not be visible from any position within 30 degrees from the horizontal line drawn normal to and through the center of the cover glass, or from any position above the compass. With the lamp operating at rated voltage, the brightness over the markings 20 degrees each of the lubber's line shall be between 0.2 and 1.5 foot lamberts. For all other visible markings on the compass, the brightness shall be between 0.1 and 1.5 foot lamberts.
- 3.4.9 Compass liquid: The compass liquid shall be in accordance with Specification MIL-L-5020.

3.5 Interchangeability:

All parts having the same manufacturer's part number shall be directly and completely interchangeable with each other with respect to installation and performance. Changes in manufacturer's part numbers shall be governed by the drawing number requirements of Specification MIL-D-70327.

3.6 Screw threads:

Screw threads 0.060 inch or larger in diameter shall be in accordance with Specification MIL-S-7742.

3.7 Weight:

The weight of the compass shall not exceed 14 ounces.

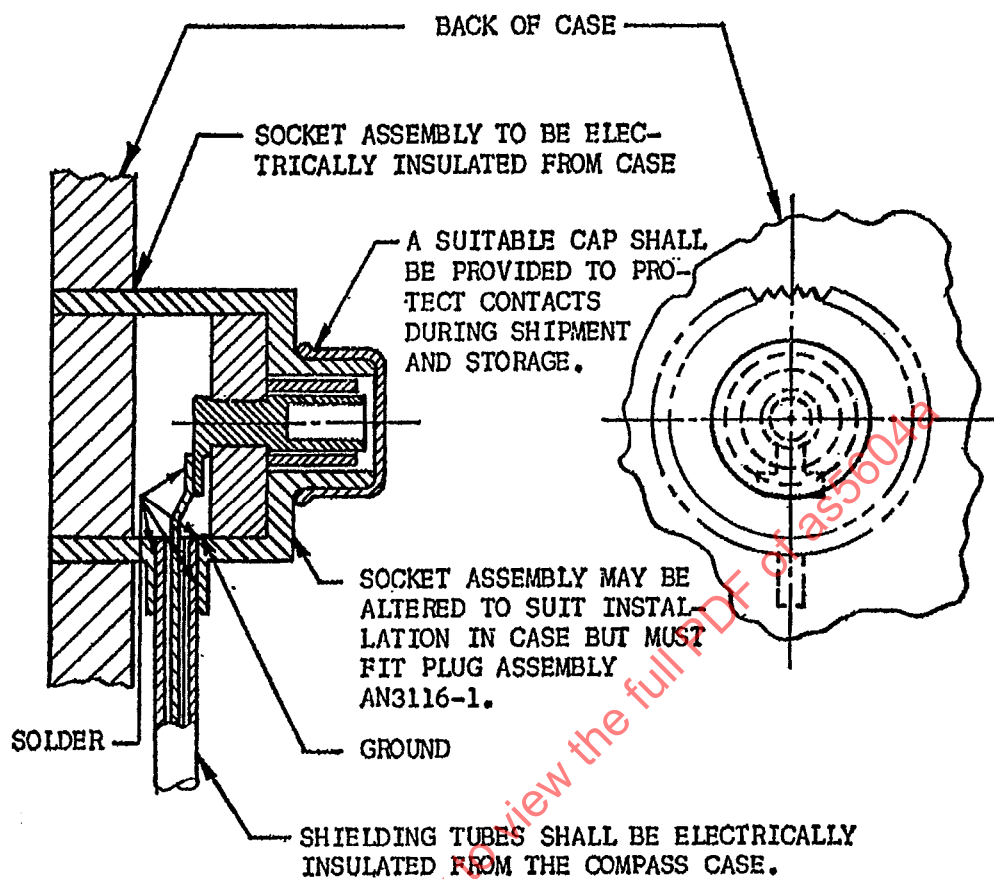


FIGURE 2. Connector Socket

3.8 Finish:

Protective coatings and finishes which will crack, chip, or scale due to normal service life or during extremes of atmospheric conditions shall not be used.

- 3.8.1 Aluminum alloy parts: Where practicable, aluminum alloy parts shall be covered with an anodic film conforming to Specification MIL-A-8625. Aluminum alloys which do not anodize satisfactorily shall be coated with a chemical film in accordance with Specification MIL-C-5541.
- 3.8.2 Iron and steel parts: Where practicable, steel parts shall be cadmium plated in accordance with Specification QQ-P-416, or zinc plated in accordance with Specification QQ-Z-325.
- 3.8.3 Exposed metallic parts: Exposed metallic parts, except electrical receptacles, or as otherwise specified, shall be coated with durable black baked enamel or other durable black finish. All external surfaces which are visible to the pilot when the compass is mounted shall have a durable black finish with minimum gloss.
- 3.8.4 Brass and bronze parts: All brass, bronze, or copper-bearing alloys, except bearing surfaces coming in contact with the compass liquid, shall be cadmium plated in accordance with Specification QQ-P-416, chromium plated in accordance with Specification QQ-C-320, zinc plated in accordance with Specification QQ-Z-325, or tin plated and finished in a durable black acceptable to the procuring activity.
- 3.8.5 Exposed phenolic material: Exposed phenolic material shall have a durable black finish.
- 3.8.6 Surfaces exposed to compass liquid: Interior surfaces of the bowl and all interior visible parts shall be finished in durable dull black. The finish shall be such that continuous or intermittent exposure to the compass liquid will not discolor or otherwise contaminate the liquid nor impair the finish.
- 3.8.7 Soldering: Soldering shall be performed in accordance with Specification MIL-S-6872.

3.9 Performance:

The compass shall satisfy the performance requirements specified in the applicable test methods of Section 4.

3.10 Markings:

All markings shall be durable to withstand usage encountered in service. The color of the markings shall be lusterless white, Color No. 37875 of Standard FED-STD-595 or fluorescent-luminescent material conforming to Specification MIL-L-25142, as specified by the procuring service (see 6.2).

- 3.10.1 Face: The card and lubber's line shall be marked as shown on Figure 1. The form of the letters and numerals on the card shall conform to Standard MS33558.
- 3.10.2 Numerals: Numerals shall distinctly indicate the graduation to which each applies. Any confusion resulting in doubt as to which graduation the numeral applies shall be cause for rejection. When several numerals are used in one group, the space between the numerals shall be approximately 1/64 inch.

3.11 Identification of product:

A suitable nameplate shall be securely attached to the compass and shall be marked in accordance with Standard MIL-STD-130.

3.12 Filling:

The compass shall be thoroughly cleaned at the proper stage of assembly and shall be completely filled with compass liquid at a temperature of approximately 68°F (20°C). In the case of the "Air chamber" type compass, the compass shall be filled sufficiently with compass liquid to allow for expansion space at the specified temperature.

3.13 Installation:

- 3.13.1 Installation instructions: Unless otherwise specified by the procuring activity, the contractor shall furnish with each compass one printed copy of instructions, with illustrations and diagrams if necessary, covering the installation of the compass. Prior to printing, two copies shall be furnished to the procuring activity for approval. Instructions shall be printed on paper 8-1/2 by 11 inches or 11 by 17 inches.
- 3.13.2 Mounting screws: The contractor shall furnish sufficient mounting screws for installing the compass. The screws shall be No. 6-32 NC-2, round head, brass machine screws having a durable and lusterless black oxidized or lusterless black nickel finish. The length shall be sufficient for mounting on a panel up to 3/8 inch thick.
- 3.13.3 Envelope: An envelope furnished by the contractor, containing installation instructions and mounting screws, shall be packaged with each compass. The envelope shall be marked with the following information:

"IMPORTANT
THIS ENVELOPE CONTAINS INSTRUCTIONS AND MOUNTING SCREWS"

3.14 Workmanship:

The compass, including all parts and accessories, shall be constructed and finished to produce an instrument free from all defects which would affect proper functioning in service. Particular attention shall be given to neatness and thoroughness of soldering, wiring, impregnation of coils, marking of parts and assemblies, welding and brazing, painting, riveting, machine-screw assemblies, and freedom of parts from burrs and sharp edges.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for inspection:

Unless otherwise specified in the contract, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Classification of inspection:

The inspection of the compass shall be classified as follows:

- (a) First article inspection (4.3)
- (b) Quality conformance inspection (4.4)

4.3 First article inspection:

First article inspection shall consist of all the examinations and tests of this specification.

- 4.3.1 First article samples: Unless otherwise specified, as soon as practicable after award of a contract or order, the manufacturer shall submit three compasses of each part number for first article testing. The samples shall be representative of the construction, workmanship, components, and materials to be used during production. When a manufacturer is in continuous production of these compasses from contract to contract, submission of further first article samples on the new contract may be waived at the discretion of the procuring activity (see 6.2). Approval of the first article samples or the waiving of the first article inspection does not preclude the requirements of submitting to the quality conformance inspection. The first article samples shall be furnished to the Government as directed by the contracting officer (see 6.2). Each sample size shall be plainly identified by a securely attached durable tag marked with the following information:

Sample for first article

Submitted by (name) (date) for tests in accordance with the requirements of specification

MIL-C-5604B under authorization (reference letter authorizing test)

COMPASS, MAGNETIC, PILOT'S STANDBY

Manufacturer's Part No.

MS Part No.

Name of manufacturer

- 4.3.1.1 Upon completion of the first article inspection, all the applicable inspection reports and when applicable, recommendations and comments pertinent for use in monitoring production will be forwarded to the Government quality assurance representative. The samples may be consumed or destroyed in the first article inspection and shall not be considered as part of the quantity to be delivered under contract (see 6.2).

4.4 Quality conformance inspection:

The quality conformance inspections of the compass shall consist of the individual tests and the sampling plans of this specification.

- 4.4.1 Individual tests: The individual tests of the compass shall consist of the following tests conducted on each compass:

Inspection

Zero compensation

Compass error without compensation

Friction error

Balance

4.4.2 Sampling plans and tests:

4.4.2.1 Sampling plan A: Samples shall consist of three compasses selected at random by the inspector from each lot of 100 or less compasses which have passed the Individual tests. A lot shall consist of identical compasses with the same manufacturer's part number, manufactured under substantially the same conditions and submitted at substantially the same time. Compasses which have been subjected to the Sampling plan A tests shall not be delivered on contract until they have been rebuilt, if necessary, and resubmitted to all individual tests.

4.4.2.1.1 Sampling plan A tests: The sampling plan A tests of the compass shall consist of the following tests conducted on each sample:

- Lubber line
- Compensation
- Compass error caused by compensating mechanism
- Tilt error
- Vibration error
- Low temperature operation
- High temperature operation
- Time of swing
- Damping
- Swirl
- Brightness

4.4.2.2 Sampling plan B: Unless otherwise specified, three compasses selected at random by the inspector from the first 15 compasses produced on contract and submitted within 10 days after manufacture shall be forwarded to the laboratory specified herein (see Section 6). Each sample shall be plainly identified by a securely attached durable tag marked with the following information:

Submitted by (name) (date) for production test in accordance with Contract No.

- 4.4.2.2.1 Sampling plan B tests: The sampling B tests of the compass shall consist of the following tests conducted on each sample:

Sampling plan A
Illumination
Insulation
Stability with change in magnetic latitude
High altitude-low temperature
High temperature exposure
Vibration failure
Humidity
Fungus resistance
Salt spray
Mounting lugs
Sand and dust
Yaw
Checking run
Turn

4.5 Rejection and retest:

The instructions on reworking or resubmitting rejected items shall be as specified in the General Provisions of the contract.

4.6 Test conditions:

- 4.6.1 Atmospheric conditions and magnetic field strength: Unless otherwise specified, all tests required by this specification shall be made in accordance with the requirements of Standard FED-STD-1, and with the compass in a magnetic field having a horizontal component of approximately 0.18 oersted, and a vertical component of approximately 0.54 oersted. When tests are made with atmospheric pressure, temperature, or magnetic field substantially different from the above values, proper allowance for change in instrument reading shall be made for the difference from the specified conditions.
- 4.6.2 Test readings: Unless otherwise specified before a test reading is taken the compass shall be vibrated using an electric vibrator set at 30cps, 60cps, or 120 cps with a maximum amplitude of 0.002 inch.
- 4.6.3 Position: Unless otherwise specified, the compass shall be tested in a normal operating position.
- 4.6.4 Vibration: Whenever a vibration stand is specified, it shall be a device which will vibrate at any desired frequency between 5 and 50 cycles per second, and shall subject the instrument to such vibration that a point on the vibration stand will describe, in a plane inclined 45 degrees to the horizontal plane, a circle of the diameter specified herein.

4.7 Test methods:

- 4.7.1 Inspection: Each compass shall be examined externally to determine conformance with the requirements of this specification with respect to materials, design and construction, physical requirements, marking, installation, and workmanship.
- 4.7.1.1 Foreign material inside compass case: The compass shall be held face down and rocked through a spread of approximately 40 degrees (20 degree either side of vertical) at a rate of approximately 1 cps for 5 seconds. At the end of this procedure the compass shall be placed face down for approximately 3 minutes. The compass shall then be gently raised over the inspector's head with the glass still face down. With the compass glass viewed in a light intensity of approximately 48 foot-candles of incident light, or 10 foot-lamberts of reflected light (approximately equivalent to two 100-watt incandescent lamps at 30 inches), no more than five particles, with no particle larger than 0.002 inch, shall be visible on the compass glass. Particle size may be estimated by comparison with the lubber's line, which is approximately 0.016 inch in width.
- 4.7.2 Zero compensation: This test shall be accomplished on compasses of a design where the compensator unit cannot be removed prior to the Compass error without compensation test as specified in 4.7.3, and on compasses of a design where the compensator can be removed prior to the Compass error caused by compensating mechanism test as specified in 4.7.8 and after the compensator has been installed. The compass shall be placed in a fixture with the mounting surface vertical and at right angles to the magnetic meridian when the fixture reads north. With the fixture set on north, the N-S compensating screw shall be turned until the compass reads north. Turning the screw shall cause the compass dial to move. The fixture shall then be set on east and the E-W compensating screw turned until the compass reads east. Turning the screw shall cause the compass dial to move. The fixture shall be set on south and the number of degrees the compass is in error shall be noted. This error shall be divided by 2 and the fixture shall be adjusted by the quotient. The N-S compensating screw shall then be adjusted until the compass reads south. The fixture shall be set on west and the above procedure repeated, adjusting the E-W compensator screw. The fixture shall then be set consecutively on north, east, south, west, and north. The error at positions north and east shall be within 1/2 degree, as read on fixture when the lubber line is centered on the cardinal markings of the error at south and west, respectively. The error at north is the alinement error and shall not exceed ± 2 degrees.
- 4.7.3 Compass error without compensation: The test shall be made with the compensator removed from the compass as a unit, without changing the adjustment; for compasses of such design that the compensator unit cannot be removed, the test shall be made with the compensator set at zero, using the procedure specified in 4.7.2. With the test fixture set on north, the compass shall indicate north (0.0 degree) with ± 2 degrees. The fixture shall then be turned about its vertical axis from the above position, by reference to an accurate circular scale, to each 30-degree heading. The error at any point, after allowing for alinement error shall not exceed one degree.

- 4.7.4 Friction error: The compass card shall be deflected 5 degrees from its equilibrium position, released, allowed to come to rest, and read. This procedure shall be repeated deflecting the card 5 degrees in the opposite direction. In each case the card shall return to within one degree of its original position, without vibrating or tapping the instrument.
- 4.7.5 Balance: The compass shall be held in its normal operating position. The deviation of the plane of the card from the horizontal, as determined by any suitable method, shall not exceed one degree.
- 4.7.6 Lubber line: The compass shall be held in its normal operating position. The deviation of the lubber's line from the vertical, as determined by any suitable method, shall not exceed one degree. The compass need not be subjected to the specified magnetic field for this test.
- 4.7.7 Compensation: With the vertical plane of the mounting surface at right angles to the magnetic meridian and with the E-W compensator set at zero, the N-S compensator shall be set successively to its maximum positive and maximum negative positions and the maximum card deviations noted. With the vertical plane of the mounting surface parallel to the magnetic meridian, and with the N-S compensating system set at zero, the E-W compensator shall be set successively to its maximum positive and maximum negative positions and the maximum card deviations noted. The maximum deviations produced by each compensating system shall be not less than 30 degrees nor more than 40 degrees. Introduction of changes in deviation shall be smooth and continuous. Control of the compensating screws shall readily allow small changes in compensation (2 degrees or less) throughout the compensating range from zero to maximum. Maximum compensation applied unnaturally (E-W when compass is oriented to north or south, and N-S when compass is at east or west) on either heading, shall not affect the indication on the other heading by more than 2 degrees. The compensator screw not being adjusted shall be set to zero compensation.
- 4.7.8 Compass error caused by compensating mechanism: Compasses which have been subjected to the Compass error without compensation test as specified in 4.7.3 with the compensators removed shall be subjected to the same test with compensators installed and set to zero compensation. Changes in readings of the compass from those obtained during the test specified in 4.7.3 shall be not greater than 2 degrees at any heading.
- 4.7.9 Tilt error: With the compensators removed or set to zero, the compass shall be observed and readings taken at each 30-degree heading. The compass shall then be tilted 10 degrees about a horizontal axis in pitch. The change in reading at each 30-degree heading shall not exceed 2 degrees. With the compass tilted 18 degrees about a horizontal axis in either pitch or bank, the card shall be perfectly free to revolve on its pivot, and shall be visible from a point 2 feet in front of and level with the center of the compass. At each 30-degree heading, when tilted 18 degrees about a horizontal axis in bank, the reading shall not differ by more than 5 degrees from the reading obtained with the compass in the normal position.