

MIL-C-5604B

13 SEPTEMBER 1962

SUPERSEDING

MIL-C-5604A

10 APRIL 1956

MILITARY SPECIFICATION**COMPASS; MAGNETIC, PILOT'S STANDBY**

This specification 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.

1. SCOPE

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

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

MS	Volts	No. Lamps
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)

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MIL-P-116 — Preservation, Method of
 MIL-L-5020 — Liquid, Compass, Aircraft
 MIL-E-5272 — Environmental Testing, Aeronautical and Associated Equipment, General Specification for
 MIL-C-5541 — Chemical Films for 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-P-7936 — Parts and Equipment, Aeronautical, Preparation for Delivery

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MIL-A-8625	— Anodic Coatings, for Aluminum and Aluminum Alloys
MIL-L-25142	— Luminescent Material, Fluorescent
MIL-D-70327	— Drawings, Engineering and Associated Lists

STANDARDS**FEDERAL**

FED-STD-1 — Standard for Laboratory Atmospheric Conditions for Testing

FED-STD-595 — Colors

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MIL-STD-130 — Identification Marking of U. S. Military Property

MIL-STD-143 — Specifications and Standards; Order of Precedence for the Selection of

MS25237 — Lamp — Incandescent, T-1 $\frac{3}{4}$ Bulb, Midget Flange Base

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 applicable documents 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 Qualification. The compasses furnished under this specification shall be a product,

samples of which have been tested and passed the qualification tests specified herein, and have been listed on or approved for listing on the applicable Qualified Products List.

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:

- they can be replaced by the standard parts (MS or AN) without alteration.
- 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.

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 MS3-3586 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, mag-

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netized 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 vi-

bration 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.

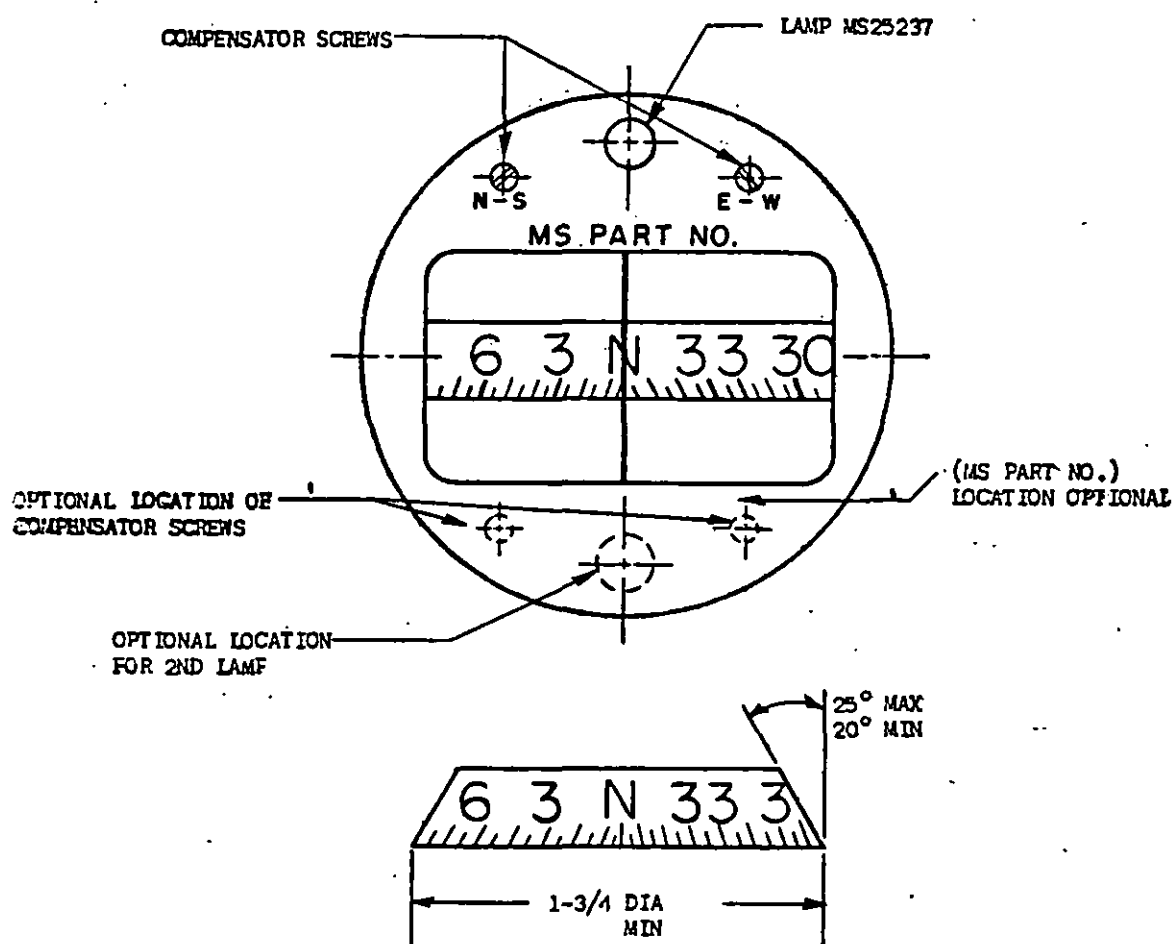
3.4.8.1 Lamp. The lamps shall conform to Standard MS25237 and shall be located substantially as shown on Figure 1. The lamp shall be replaceable in flight without the use of tools. The color shall conform to the requirements of Specification MIL-C-25050 and shall be as specified by the procuring activity (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

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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

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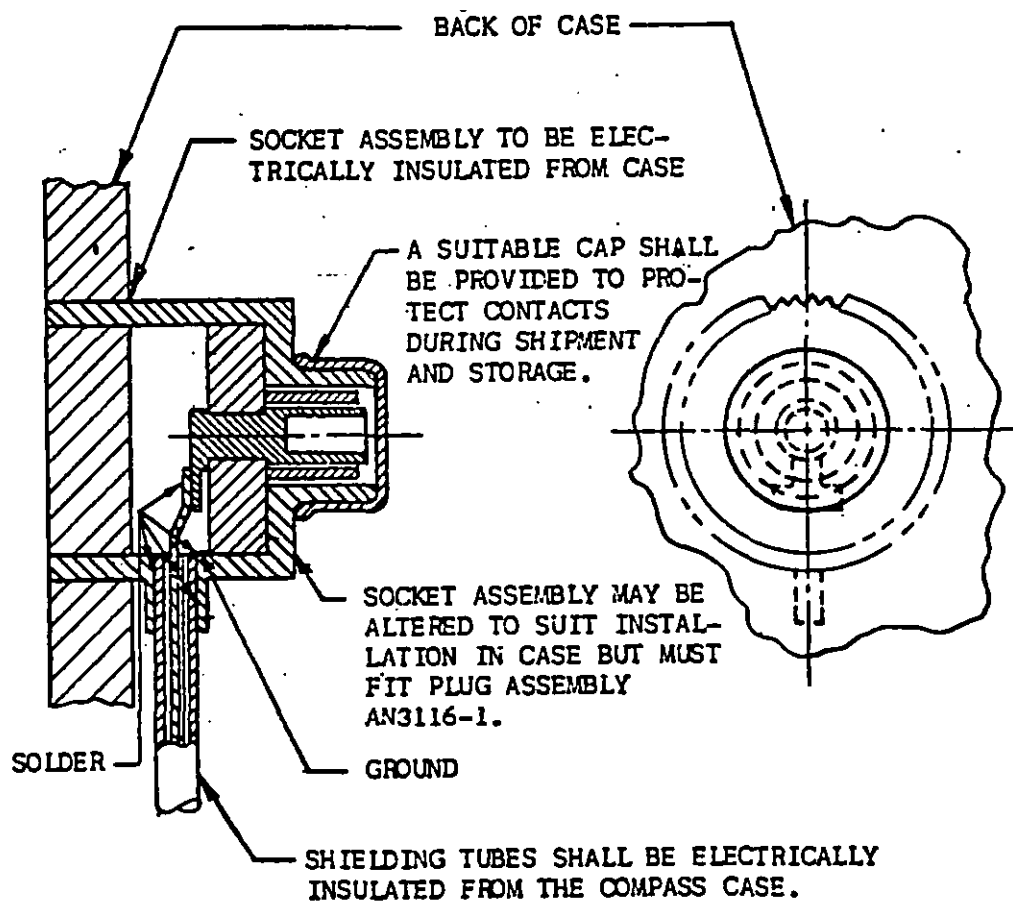


FIGURE 2. Connector Socket

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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.

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 ac-

cordance 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

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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 Contractor responsibility. The supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own or any other inspection facilities and services acceptable to the Government. Inspection records of the examination and tests shall be kept complete and available to the Government as specified in the contract or order. The Government reserves the right to perform any of the inspections set forth in the specifications where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Classification of tests. The inspection and testing of the compass shall be classified as follows:

- (a) **Qualification tests:** Qualification tests are those tests performed on compasses submitted for qualification as a satisfactory product.
- (b) **Acceptance tests:** Acceptance tests are those tests performed on compasses manufactured and submitted for acceptance under contract.

4.3 Qualification tests. The qualification tests of the compass shall consist of all tests of this specification specified under paragraph headed Test methods.

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4.3.1 Qualification test samples. The qualification test samples shall consist of three compasses of each manufacturer's part number submitted for qualification testing. After obtaining authorization for submittal from the activity responsible for qualification, the samples shall be forwarded to the testing laboratory designated in the letter of authorization. Each sample shall be plainly identified by a securely attached durable tag marked with the following information (see 6.3):

Sample for qualification tests
Submitted by (name) (date) for qualification 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

4.4 Acceptance tests. The acceptance tests 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

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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

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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.

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4.7.10 Vibration error. The compass shall be tested in accordance with Procedure IV of Specification MIL-E-5272 and shall be mounted on a vibration stand with a line joining the centers of the two lower mounting holes in a horizontal plane and with the plane of the mounting surface vertical and the heading observed. The compass shall be subjected to such vibration that a point on the case describes a circle of between 0.009 and 0.011-inch diameter at frequencies varying from 5 to 50 cycles per second. The differences between the card reading observed before vibration and during vibration shall not exceed 3 degrees.

4.7.11 Low temperature operation. This test may be combined with the High altitude-Low temperature test at the discretion of the testing agency. The compass shall be subjected to a temperature of $-67^{\circ} \pm 3.6^{\circ}\text{F}$ ($-55^{\circ} \pm 2^{\circ}\text{C}$) for a period of 6 hours. There shall be no signs of leakage or damage. While at this temperature the compass shall be subjected to the Friction error test and Balance test.

4.7.12 High temperature operation. This test may be combined with the high temperature exposure test at the discretion of the testing agency. The compass shall be subjected to a temperature of $180^{\circ} \pm 3.6^{\circ}\text{F}$ ($82^{\circ} \pm 2^{\circ}\text{C}$) for a period of 2 hours. There shall be no sign of leakage or damage. While at this temperature the compass shall be subjected to the Friction error test and Balance test.

4.7.13 Time of swing. With the compensator removed, the card shall be magnetically deflected 30 degrees from its equilibrium position, held long enough for the liquid to come to rest, then released and the time observed for the card to pass through 25 degrees toward its equilibrium position. The test shall be repeated with the card deflected 30 degrees to the other side of its equilibrium position. The average time of the two readings shall be not less than 1.4 seconds nor greater than 1.8 seconds. The position of the compass shall not be changed during the test.

4.7.14 Damping. The card shall be magnetically deflected 30 degrees from its equilibrium

position, held at this position long enough for the liquid to come to rest, then released and the overswing past the equilibrium position noted. The test shall be repeated with deflection of 30 degrees in the opposite direction. The position of the compass shall not be changed between deflections in opposite directions. The average of the two observations shall not exceed 15 degrees. The compensator shall be removed for this test if possible. If desired, this test may be combined with the Time of swing test as specified in 4.7.13.

4.7.15 Swirl. With the compass in its normal upright position at any heading and with the liquid at room temperature, the compass shall be turned through 360 degrees in 1 minute. The maximum deflection of the card from its original heading immediately following the 360-degree rotation shall not exceed 2 degrees.

4.7.16 Brightness. Measurements of brightness shall be made with lamps operated at rated voltage. Lamps shall be aged and tested for rated values. Measurements shall be made with cover glass in place and compass bowl filled. The brightness of markings shall be made with a brightness meter mounted sufficiently far from the fixture to focus on the markings of the compass. Measurements shall be made in a dark room. The test shall be made to determine that the source illuminating the compass is not visible from any position within 30 degrees of the horizontal line drawn normal to and through the center of the cover glass or from any point above the compass. The brightness shall conform to values in 3.4.8.5.

4.7.17 Illumination. With the rated voltage applied to the connector, the card markings and lubber's line shall be uniformly illuminated without glare. With voltage decreasing, the uniformity of illumination shall not appreciably vary. The compass shall be observed under conditions of both twilight and complete darkness. The compass need not be subjected to the specified magnetic field for this test.

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4.7.18 Insulation. With the lamp removed, the electrical circuit shall be subjected to a potential of 500 volts at a frequency of 60 cps for a period of 1 minute. There shall be no breakdown of insulation.

4.7.19 Stability with change in magnetic latitude. The compass shall meet the requirements of the Balance test. The compass in its normal operating position shall be subjected to a vertical component field whose magnetic intensity is zero, and to a standard horizontal component field whose magnetic intensity is 0.18 oersted. Such a field may be produced by means of a Helmholtz coil. The deviation of the plane of the card from the horizontal as determined by any suitable method shall not exceed 3 degrees.

4.7.20 High altitude—low temperature. The compass shall be placed in a chamber and maintained at a temperature of $-85^{\circ} \pm 3.6^{\circ}\text{F}$ ($-65^{\circ} \pm 2^{\circ}\text{C}$) and a pressure altitude equivalent to 50,000 feet (3,436 inches of mercury absolute) for 4 hours. The compass shall then be maintained at a temperature of $-85^{\circ} \pm 3.6^{\circ}\text{F}$ ($-65^{\circ} \pm 2^{\circ}\text{C}$) (atmospheric pressure) for an additional period of 44 hours. During this test, no bubble larger than 1 inch shall appear on the bowl. In the "Air chamber" type compass no bubble shall appear in the normal upright position. Any bubble which might have formed at $-85^{\circ} \pm 3.6^{\circ}\text{F}$ ($-65^{\circ} \pm 2^{\circ}\text{C}$) shall completely disappear after 2 hours at room temperature. In the "Air chamber" type compass, no bubble shall show on the window of the compass up to an 18-degree tilt angle. The compass need not be subjected to the specified magnetic field for this test.

4.7.21 High temperature exposure. The compass shall be tested in accordance with Procedure II of Specification MIL-E-5272. After the chamber has been returned to room temperature and the compass has saturated at room temperature for a minimum period of 4 hours, it shall be subjected to and meet the requirements specified in the Individual tests. There shall be no damage which would adversely affect subsequent operation. The compass need not be subjected to the specified magnetic field for this test.

4.7.22 Vibration failure. The compass shall be tested in accordance with Procedure V of Specification MIL-E-5272. At the completion of this vibration, the compass shall meet the requirements of the Friction error test specified in 4.7.4. No screws or other parts shall become loose, and no leakage shall occur during vibration. The compass need not be subjected to the specified magnetic field for this test.

4.7.23 Humidity. The compass shall be tested in accordance with Procedure I of Specification MIL-E-5272, except that the test period shall be for 120 hours (5 cycles). Within 1 hour after the completion of the humidity exposure, the compass shall be subjected to and meet the requirements specified in the Individual tests. Between 24 and 48 hours after the completion of the humidity exposure, the compass shall be examined, and there shall be no evidence of corrosion or deterioration that will affect subsequent operation. The compass need not be subjected to the specified magnetic field for this test.

4.7.24 Fungus resistance. The compass shall be tested in accordance with Procedure I of Specification MIL-E-5272, except that the test period shall be for a minimum of 14 days. The compass need not be subjected to the specified magnetic field for this test. At the conclusion of this test, visual inspection shall be made of the compass to determine that no growth of fungus has occurred. At the option of the activity responsible for qualification, tests on component parts of the instrument may be accepted in lieu of or in addition to tests on the assembled instrument.

4.7.25 Salt spray. The compass, with external connections made to simulate installed conditions, shall be subjected to a salt spray in accordance with Procedure I of Specification MIL-E-5272 for a period of 50 hours. The compass need not be subjected to the specified magnetic field for this test. At the end of the 50-hour period, the compass shall be subjected to and meet the requirements specified in the Individual tests.

4.7.26 Mounting lugs. The compass case, with mechanism removed, shall be mounted

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face downward on the movable head of a suitable testing machine with the face of the case in a horizontal plane, in order that the mounting lugs receive no added support. A suitable pin shall be inserted through the hole in the mounting lug and attached to a pull strap in the stationary head of the machine. A load of 175 pounds shall be applied along the axis toward the front of the case for a period of 1 minute. The lugs shall withstand the applied load without fracture and there shall be no damage to any part of the compass.

4.7.27 Sand and dust. The compass shall be tested in accordance with Procedure I of Specification MIL-E-5272. There shall be no damage which would seriously affect the operation of the compass or the compensating system. The compass shall be subjected to and meet the requirements of the Friction test. In addition, satisfactory operation of the compensator adjustments shall be determined as specified in 3.4.7.1.

4.7.28 Yaw. The compass shall be installed as specified in 4.7.30. Readings shall be taken as described herein, and the aircraft shall be kept as nearly level as practicable. The determinations shall be made in smooth air. When the aircraft is made to yaw 5 degrees to each side about a "north magnetic" heading at the rate of 5 complete oscillations per minute, the compass shall indicate at all times the correct heading with an error not exceeding 15 degrees.

4.7.29 Checking run. The compass shall be installed in an aircraft, preferably one equipped with and flown by an automatic pilot. Installation of compass and readings shall be made in the manner specified in 4.7.30. When the aircraft is flown in a "north magnetic" heading for 3 minutes in moderately rough air, the compass shall indicate the correct heading at all times with an error not exceeding 20 degrees, provided the heading has not changed more than 5 degrees and provided the rate of change of heading has not exceeded 1 degree per second.

4.7.30 Turn. The compass shall be installed in a suitable aircraft, compensated, and cor-

rections for residual deviations shall be made. A directional gyro or accepted stabilized magnetic compass shall be used to determine standard headings. Photographic records of the indications of the compass under test and of the standard gyro or compass shall be made at least once each second. The determination shall be made in smooth air. Following a turn from "magnetic north" to "magnetic south" at the rate of 180 degrees per minute, the compass shall indicate the correct heading 6 seconds after the completion of the turn with an error not exceeding 10 degrees.

5. PREPARATION FOR DELIVERY

5.1 Packaging. The compass shall be packaged in accordance with Specification MIL-P-7936, Level A or B, as specified in contract or order (see 6.2). For Level A packaging the method of preservation shall be in accordance with Specification MIL-P-116, Method II, without preservative compound, using metal reusable containers unless otherwise specified.

5.2 Packing. The compass shall be packed in accordance with Specification MIL-P-7936, Level A, B, or C, as specified in contract or order (see 6.2).

5.3 Marking. The interior and exterior containers shall be marked as specified in Specification MIL-P-7936.

6. NOTES

6.1 Intended use. The compass covered by this specification is intended for use as a pilot's standby steering compass, for use in airplanes that are equipped with a remote indicating compass. The standby compass is intended to continuously indicate the heading of the airplane with reference to the earth's magnetic field.

6.2 Ordering data. Procurement documents should specify the following:

- (a) Title, number, and date of this specification
- (b) Whether Sampling plan B is to be omitted or name of the laboratory where samples shall be submitted.

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- (c) Levels of packaging and packing desired.
- (d) Whether compass is to be supplied with or without lamps.
- (e) Color of lamps.
- (f) Color of dial markings.
- (g) Type of container to be used for preservation.

6.3 Qualification. With respect to products requiring qualification, awards will be made only for such products as have, prior to the time set for opening of bids, been tested and approved for inclusion in the applicable Quali-

fied Products List whether or not such products have actually been so listed by that date. The attention of the suppliers is called to this requirement, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for the qualified products list is the Chief, Bureau of Naval Weapons, Department of the Navy, Washington 25, D. C., and information pertaining to qualification of products may be obtained from that activity.

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