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MILITARY SPECIFICATION  
 COMPASS, MAGNETIC, MOUNTED

1 SCOPE

\*1.1 This specification covers the requirements for two types of integrally lighted pilot's standby mounted magnetic compasses.

\*1.2 Classification Compasses shall be of the following types, as specified (see 6.2):

AQU-3/A	White lighted
AQU-5/A	Red lighted

\*2. APPLICABLE DOCUMENTS

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

SPECIFICATIONS

Federal

QQ-C-320	Chromium Plating (Electrodeposited)
QQ-P-410	Plating, Cadmium (Electrodeposited)
QQ-T-425	Tinplate (Hot Dip and Electrolytic)
QQ-Z-325	Zinc Coating, Electrodeposited, Requirements for
PPP-B-566	Box, Folding, Paperboard
PPP-B-636	Box, Fiberboard
PPP-B-665	Box, Paperboard, Metal Stayed (Including Stay Material)
PPP-B-676	Box, Setup

Military

MIL-P-116	Preservation, Methods of
MIL-L-5020	Liquid, Compass, Aircraft
MIL-C-5541	Chemical Films and Chemical Film Materials for Aluminum and Aluminum Alloys
MIL-S-7742	Screw Threads, Standard, Optimum Selected Series: General Specification for

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MIL-A-8625 Anodic Coatings, for Aluminum and Aluminum Alloys  
 MII -C-14806 Coating, Reflection Reducing, for Instrument Cover Glasses and Lighting Wedges  
 MIL-L-25467 Lighting, Integral, Aircraft Instrument, General Specification for  
 MIL-L-27160 Lighting, Instrument, Integral, White, General Specification for  
 MIL-B-27497 Bearing, Jewel, Sapphire or Ruby, Synthetic

STANDARDSMilitary

MIL-STD-100 Engineering Drawing Practices  
 MIL-STD-129 Marking for Shipment and Storage  
 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-454 Standard General Requirements for Electronic Equipment  
 MIL-STD-781 Reliability Tests, Exponential Distribution  
 MIL-STD-794 Parts and Equipment, Procedures for Packaging and Packing of  
 MIL-STD-810 Environmental Test Methods  
 MIL-STD-831 Test Reports, Preparation of  
 MS33558 Numerals and Letters, Aircraft Instrument Dial, Standard Form of  
 MS33586 Metals, Definition of Dissimilar

## Air Force - Navy Aeronautical

AN3116 Plug Assembly - Instrument Electrical

(Copies of documents required by suppliers in connection with specific procurement functions may 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 products which are qualified for listing on the applicable Qualified Products List at the time set for opening of bids (see 4.4 and 6.4)

3.2 Selector of specifications and standards Specifications and standards for necessary commodities and services not specified herein shall be selected in accordance with MIL-STD-143.

3.3 Materials

3.3.1 Metals. Metals shall be of the corrosion-resistant type or suitably protected to resist corrosion during normal service life. Materials contained within hermetically sealed enclosures are considered to be suitably protected against corrosion.

3.3.1.1 Dissimilar metals Dissimilar metals shall not be used in intimate contact unless suitably protected against electrolytic corrosion. Dissimilar metals are defined in MS33586

3.3.1.2 Light metal alloys Aluminum, magnesium, and other lightweight alloys shall be used for all metal parts of the compass except where stressing, fire resistance, or other requirements dictate the use of steel or other heavy metals

3.3.2 Nonmagnetic materials. Nonmagnetic materials shall be used for all parts of the compass except where magnetic materials are essential

3.3.3 Fungus-resistant materials. Materials which are not nutrients for fungi shall be used to the greatest extent practicable. In cases where materials that are nutrients for fungi must be used, such materials shall be treated with a fungicidal agent as approved by the procuring activity

3.3.4 Protective treatment When materials are used in the construction of the compass that are subject to corrosion due to salt air or other atmospheric conditions likely to occur during service usage, they shall be protected against such corrosion in a manner that will in no way prevent compliance with the performance requirements of this specification. The use of any protective coating that will crack, chip, or scale with age or extremes of atmospheric conditions shall be avoided

3.4 Design The compass shall be designed to operate as a reference to the earth's magnetic meridian. The outline dimensions of the compass shall conform to figures 1 and 2. The design shall be as simple as practicable so that overhaul or repair may be accomplished readily without the use of special tools or fixtures

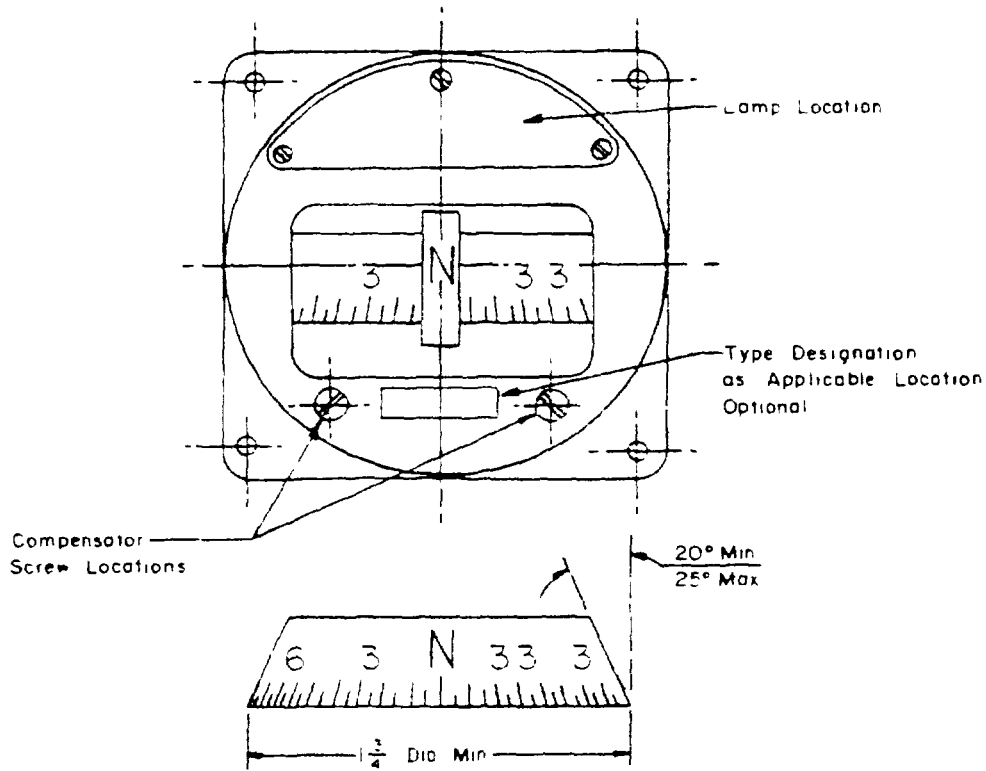
3.4.1 Mounting flange The mounting flange shall be an integral part of the compass

3.4.2 Filler cap A suitable filler cap shall be so incorporated that the compass may be easily filled with liquid

3.4.3 Bowl The bowl shall be made of low-density metal, shall be uniform in texture, have a smooth surface, and shall be of one-piece construction. If approved by the procuring activity, other types of construction may be used. A V-channel shall be cut into the top of the inside of the bowl so that one side of the channel meets the coverglass at not more than 70°, except this channel will not be required on compasses of the bellows- or expansion-type construction. The channel shall run the full length of the top edge of the glass (as viewed from the outside) and shall be not less than 1/8 inch deep. Holes shall be drilled in the bottom of the channel so that air can rise to the chamber above. No bubbles shall be visible in the face of the compass when the compass is tilted at an 18° dive.

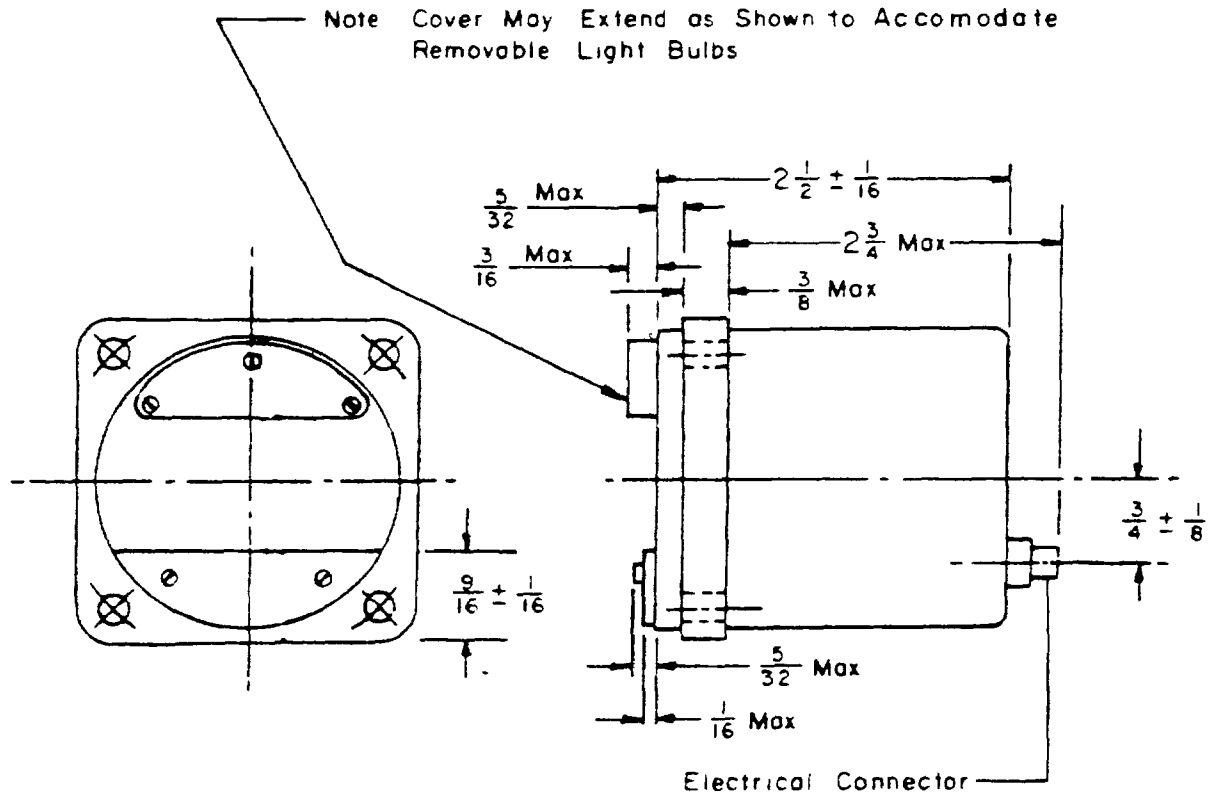
3.4.3.1 Cover glass. The cover glass shall be of the flat type, shall be thoroughly annealed, and shall be free from flaws and scratches. The size of the cover glass shall be such that not less than 60° of the card graduations, ±30° from the lubber line, are exposed for viewing along the line of sight which makes an angle of 30° with any point on the perimeter edge of the cover glass.

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MARKING	HEIGHT OR LENGTH ±0.010	WIDTH OF LINE ±0.005	COLOR
Numerals 3, 6, 12, 15, 21, 24, 30 and 33	0.187	—	White
30° Graduations	0.094	0.031	White
10° Graduations	0.094	0.016	White
Cardinal Pointers N, E, S, W	0.187	—	White
Lubber Line (Approx) 5° Graduations	0.750 0.062	0.016 0.016	White
(Type No. ,	0.062	—	Durable Black

FIGURE 1. Face and Card Detail



See Figure 1 For Face and Card Details

Case in Accordance with MS33638 For 2-inch Nominal Size Except as Shown

Dimensions in Inches

FIGURE 2. Case

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3 4.3 1.1 The glass shall be clear and free from flaws that would affect the legibility of the card markings when the compass is filled with liquid and observed under normal operating conditions

\*3 4.3 1.2 Reflecting glass surfaces All reflecting glass surfaces, except the surface adjacent to the compass fluid, shall be provided with a reflection-reducing coating conforming to MIL-C-14806

3 4.3 2 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 3 Expansion unit Except for the air-chamber type, 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 4.4 Compass liquid The compass liquid shall be in accordance with MIL-L-5020

\*3 4.4 1 Filling procedure At the proper stage of assembly, the compass shall be completely filled with the liquid specified in 3 4.4 at a temperature of 20°C. The compass shall then be sealed. In the case of an air-chamber-type compass, the compass shall be filled with compass liquid to such a level as to allow for expansion space at the specified temperature. With the filler cap removed, the compass shall be placed in an altitude chamber, the pressure reduced to the equivalent of a 50,000-foot altitude and maintained for a period of 20 minutes, and the pressure then increased to sea level. Any drop in liquid level shall be replenished and the filler cap shall be installed.

\* 3.4 4.2 Leakage. Under no circumstances shall the liquid leak from the compass when it is subjected to the environments specified herein.

3 4.5 Compass face. Each compass-face numeral shall distinctly indicate the graduation to which it applies

3.4.5.1 Markings All markings shall be so durable as to withstand usage encountered in service. The card and lubber line shall be marked as shown on figure 1. The form of the letters and numerals on the card shall conform to MS3355E.

3.4.5.2 Card assembly. The card assembly shall be as lightweight as practicable and shall be sufficiently rigid to withstand service usage. The assembly shall be spring mounted to absorb the external vibration encountered in service. Caution shall be exercised in soldering to prevent heating of the magnet.

\*3 4.5.2.1 Card The card shall be constructed of aluminum, aluminum-alloy, or other nonmagnetic material, and shall be graduated at 5° divisions to represent horizontal angles, as shown on figure 1, within an accuracy of 1°. When the compass is tilted 18° in pitch up and down, all compass card letters, numerals, and markings shall be clearly readable.

3 4 5 2.2 Card pivot The card pivot shall be constructed of high-grade steel or other suitable alloy which shall be properly hardened and polished on its working surface

\*3 4.5.2 3 Lubber line The lubber line shall be made of phosphor bronze, brass, berrilium copper, or similar nonferrous metal properly plated so that it will not discolor the fluid, and shall be so constructed that when reading the card, parallax will be reduced to a minimum. A plane through the pivot and the lubber line shall form right angles with the plane of the mounting surface within an accuracy of 1°.

3 4 5 3 Compensating systems The compensating system shall consist of permanent bar magnets that are manually adjustable for removing the compass deviations on North-South (N-S) and East-West (E-W) 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 system shall be so designed that the zero index mark reads zero only when the system is in its zero effect position.

3 4.5.3 1 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 4.5.3 2 Cup jewel The cup jewel shall be sapphire in accordance with MIL-B-27497, shall be free from surface flaws, and shall fit snugly in the jewel retainer.

3 4 5 3.3 Magnets The compensating and card magnets shall be made of suitable magnetic material, shall be heat-treated, magnetized to saturation, and aged to insure optimum performance.

\*3 4 6 Lighting system Except as specified herein, the AQU-5 A compass shall be provided with an integral red lighting system in accordance with MIL-L-25467 and the AQU-3 A compass shall be provided with a white lighting system in accordance with MIL-L-27160.

\*3 4 6 1 Prime standard Internal lighting shall be comparable to and shall balance in brightness with prime standard compasses. The prime standard shall be either a standby compass or a lighted model conforming to the requirements of this specification. The prime standard shall be equipped with the applicable lighting, shall meet all specification requirements, and shall be used as the reference for acceptance of all standby compasses. The prime standard and recorded overall color and brightness measurements shall be approved by the procuring activity.

\*3 4 6 1.1 Color and brightness areas. Representative areas of the face of the prime standard shall be measured for color and brightness in accordance with MIL-L-25467 or MIL-L-27160, as applicable. Checks shall be made every 50 hours of operation or 120 days to determine any brightness or color change. The prime standard data shall be submitted to the procuring activity for investigation and reapproval. The procuring activity reserves the right to request that the prime standard be submitted for investigation.

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\*3.4.6.2 Visual comparison When both the compass and the prime standard are energized with  $3.0 \pm 0.01V$ , the compass shall appear no brighter or dimmer than the prime standard. When the AQU-5/A indicator and the prime standard are energized with  $5.0 \pm 0.01V$  or when the AQU-3 A indicator and compass are energized with  $4.5 \pm 0.01V$ , the compasses shall appear identical in color to the prime standard.

\*3.4.6.3 Lamp circuit The lamp circuit between the lamp socket and connector socket shall be a properly counterpoised system that will not produce a stray magnetic field which would cause compass errors in excess of those specified in 3.4.6.3 with direct current applied and the lamp burning.

3.4.6.3.1 Electrical connector socket. The electrical connector socket shall conform to figure 3.

3.4.7 Adjustment of compensator The adjustment of the compensator shall be made from the front of the compass. Each system shall be provided with a screwdriver-type adjustment. The change in compensation for equal angular displacements of the adjusting screws shall be the same for both N-S and E-W systems. Either adjustment may be turned continuously in one direction without meeting a stop which shall result in the compensation passing through complete cycles repeatedly.

3.4.7.1 Friction There shall be sufficient friction in the adjustment operation to prevent changes in adjustment due to vibration.

3.4.8 Service conditions The compass shall be suitable for continuous operation for extended periods of time under all service conditions.

\*3.4.9 Maintainability The following maintainability requirements shall be considered in the design of the compass:

a. Minimization of the complexity of maintenance tasks (for example calibration, adjustments, inspection, etc) by maximum use of simple design which includes optimum interchangeability and use of standardized equipment or commercial items.

b. Rapid and positive recognition of equipment malfunction or marginal performance.

c. Rapid and positive identification of the replaceable defective part, assembly or component.

d. Minimum numbers and types of tests and test equipment (special and standard) needed to perform maintenance.

\*3.4.10 Reliability. The compass shall demonstrate a minimum acceptable mean-time-between-failures (MTBF) of 2,000 hours based on a discrimination ratio of 0.67 and a confidence factor of 90 percent.



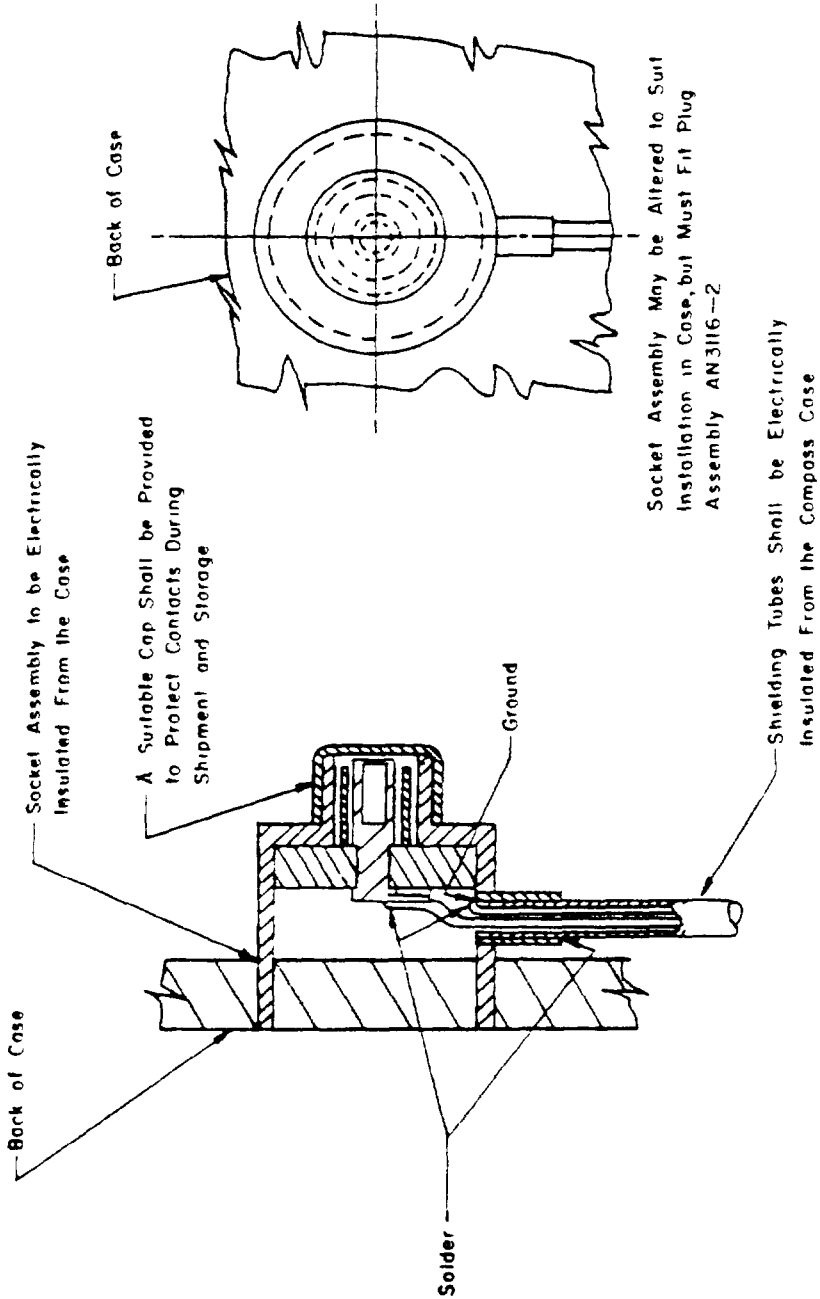


FIGURE 3. Connector Socket

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\*3.4.11 Longevity The compass shall have an operating life of not less than 3,000 hours before the equipment consistently fails to meet the specified M TBF.

3.5 Construction The compass shall be so constructed that no parts will work loose in service. It shall be built to withstand the strains, jars, vibration, and other conditions incident to shipment, storage, installation, and service use.

\*3.6 Performance The compass shall function properly under the following conditions:

a. Temperatures - operating temperatures ranging from -54° to +71°C and storage temperatures ranging from -62° to +71°C

b. Humidity - relative humidity up to 95 percent at a temperature of 71° ±2°C

c. Altitude - altitudes ranging from 0 to 80,000 feet

d. Salt fog - exposure to atmosphere containing salt laden moisture for a minimum of 168 hours

e. Vibration - conditions of vibration incident to normal use in aircraft; or any variation in vibration frequency between the limits of 5 and 500 Hz and circular amplitudes between 0.009 and 0.011 inch diameter

f. Fungus - Fungus growth as encountered in tropical climates

g. Dust - Exposure to airborne sand and dust particles as encountered in desert areas

h. Thermal shock - abrupt temperature change from 71° to 5°C

i. Shock - accelerations up to 10g for a nominal duration of 10 milliseconds.

3.6.1 Functions The compass shall function as a pilot's standby magnetic compass for use in aircraft equipped with a remote indicating compass. When properly installed in the aircraft, the compass shall be capable of performing the following functions under flight conditions:

a. Continuously indicate the heading of the aircraft with reference to the earth's magnetic field

b. Indicate the correct heading with an error not exceeding 10° within 6 seconds after completing a turn from magnetic north to magnetic south at the rate of 360° per minute

c. Indicate the correct heading with an error not exceeding 3°, provided the rate of change of heading does not exceed 1° per second, in moderately rough air on a north magnetic heading.

\*3 6.2 Insulation. The compass shall withstand a potential of 500V at a frequency of 60 Hz applied between pins and between pins and the case for a period of 1 minute.

\*3 6.3 Mounting lugs The mounting lugs shall withstand a load of 175 pounds for a period of 1 minute under the conditions specified in 4.6.19.

\*3 6.4 Connector installation. The connector shall be of such strength and shall be so installed that it will withstand a moment of 25 inch-pounds for 1 minute without becoming damaged or loosened

\*3 7 Part numbering of interchangeable parts All parts having the same manufacturer's part number shall be functionally and dimensionally interchangeable. The item identification and part number requirements of MIL-STD-100 shall govern the manufacturer's part numbers and changes thereto

3 8 Screw threads Unless otherwise specified, screw threads shall conform to MIL-S-7742

\*3 9 Soldering Soldering shall be in accordance with MIL-STD-454, requirement 5

### 3.10 Finishes and protective coatings

3.10.1 Aluminum alloy parts Aluminum alloy parts shall be covered with an anodic film conforming to MIL-A-8625, except as follows

a Dials, small holes, and case inserts need not be anodized

b Aluminum alloys which do not anodize satisfactorily shall be coated with a chemical film in accordance with MIL-C-5541

c Where the primary purpose of the treatment is to afford a suitable paint base, chemical treatments in accordance with MIL-C-5541 may be used in lieu of anodizing

d Castings containing nonaluminum alloy integral inserts may be treated with a chemical film in accordance with MIL-C-5541 in lieu of anodizing

3.10.2 Steel parts Where practicable, steel parts shall be cadmium plated in accordance with QQ-P-416, of a class and type adequate to achieve the degree of protection required, or zinc plated in accordance with QQ-Z-325.

3.10.3 Brass and bronze parts All brass, bronze, or copper-bearing alloys, except bearing surfaces which come in contact with the compass liquid, shall be cadmium-plated in accordance with QQ-P-416, of a class and type adequate to achieve the degree of protection required; chromium-plated in accordance with QQ-C-320, zinc-plated in accordance with QQ-Z-325; or tin-plated in accordance with QQ-T-425.

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3 10 4 Interior finish. The interior surface of the bowl and all interior visible parts shall be finished in durable dull black as approved by the procuring activity. 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 10 5 Exposed metallic parts Except as otherwise specified, exposed metallic parts, except electrical receptacles, shall be coated with durable black baked enamel or other durable black finish. All external surfaces that are visible to the pilot when the compass is mounted shall have a durable black finish with minimum gloss.

3 11 Weight The total weight of the compass shall not exceed 14 ounces.

3 12 Identification of product Equipment, assemblies, and parts shall be marked for identification in accordance with MIL-STD-130

3 13 Workmanship The compass, including all parts and accessories shall be constructed and finished in a thoroughly workmanlike manner. Particular attention shall be given to neatness and thoroughness of soldering, marking of parts and assemblies, and freedom of parts from burrs and sharp edges.

3 13 1 Dimensions and tolerances Dimensions and tolerances not specified shall be as close as is consistent with the best shop practices. Where dimensions and tolerances may affect the interchangeability, operation, or performance of the compass, they shall be held or limited accordingly.

3 13 2 Screw assemblies Assembly screws and bolts shall be tight. The word tight means that the screw or bolt cannot be appreciably tightened further without damage or injury to the screw, bolt, or threads.

3 13 3 Cleaning The compass shall be thoroughly cleaned and loose, spattered, or excess solder, metal chips, and other foreign material removed during and after final assembly. Burrs and sharp edges as well as resin flash that may crumble shall be removed.

3 13.4 Riveting Riveting operations shall be carefully performed and shall be operable without interference, tight spots, loose spots, or other irregularities. Where required for accurate adjustments gear assemblies shall be free from backlash.

#### 4 QUALITY ASSURANCE PROVISIONS

4 1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier 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 tests The inspection and testing of compasses shall be classified as follows

- a. Qualification tests
- b. Quality conformance tests

#### 4.3 Test conditions

4.3.1 Atmospheric pressure Unless otherwise specified, all tests shall be made at atmospheric pressure (approximately 29.92 inches Hg) and at room temperature (approximately 25°C). When the tests are made with atmospheric pressure or room temperature differing materially from the above values, proper allowance shall be made for the differences from the specified conditions.

4.3.2 Friction removal Unless otherwise specified, the compass shall be vibrated before a test reading is taken. Vibration shall be applied by means of an electromechanical vibrator and shall be approximately 0.2g at a frequency of not less than 30 Hz.

4.3.3 Attitude Unless otherwise specified, the compass shall be tested in the normal operating position.

4.3.4 Vibration stand A vibration stand shall be used that will vibrate with a circular motion in a plane inclined 45° to the horizontal plane at frequencies between 5 and 500 Hz. The diameters of the circles shall be as specified herein.

#### 4.4 Qualification testing

\*4.4.1 Test samples. The test samples shall consist of 18 compasses representative of the production equipment. Three of the compasses shall be subjected to all the tests except reliability and the other 15 compasses shall be subjected to the reliability test only (see 4.6.29). The samples shall be identified with the manufacturer's part number and such other information as required by the procuring activity.

\*4.4.2 Test report When tests are conducted at a location other than the laboratory of the qualifying activity, the following shall be furnished to that activity:

- a. Three copies of a test report in accordance with MIL-STD-831
- b. The samples that were tested in the "as is" condition
- c. Two sets of assembly drawings
- d. Brief operating instructions.

4.4.3 Qualification tests. The qualification tests shall consist of all the tests described under 4.6.

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4 5 Quality conformance tests. Quality conformance tests shall consist of

- a. Individual tests
- b. Sampling tests.

4 5.1 Individual tests Each compass shall be subjected to the following tests as described under 4 6

- a. Examination of product
- b. Tilt error
- c. Zero compensation
- d. Compass error without compensation
- e. Friction error
- f. Balance
- g. Early failure
- h. Lighting (visual comparison only).

4 5 2 Sampling tests

4 5 2 1 Sampling plan A Five compasses shall be selected at random from each 100 or fraction thereof produced on the contract or order and subjected to the following tests as described under 4 6

- a. Individual tests
- b. Compensation
- c. Compass error caused by compensating mechanism
- d. Low temperature operation
- e. High temperature operation
- f. Time of swing
- g. Vibration error
- h. Damping

- i Swirl
- j Lubber line
- k Insulation
- l Mounting lugs
- m Connector installation
- n Stability with change in magnetic latitude.

\*4 5 2 2 Sampling plan B Unless otherwise specified (see 6.2), 3 compasses shall be selected at random from the first 15 on the contract or order and subjected to the following tests as described under 4.6

- a. Sampling plan A tests
- b Temperature-altitude
- c. Thermal shock
- d Shock
- e Humidity
- f Fungus
- g Salt fog
- h Dust
- i Vibration
- j High temperature exposure
- k Low temperature exposure.

4 5 2 2.1 At the option of the procuring activity, the tests specified in 4 5.2 2c, d, e, and f may be conducted on empty cases.

4.5.2.3 Rejection and retest. When one item selected from a production run fails to meet the specification, no item still on hand or later produced shall be accepted until the extent and cause of failure are determined. After corrections have been made, all necessary tests shall be repeated.

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4 5.2.3.1 Individual tests may continue. For operational reasons, individual tests may be continued pending the investigation of a sampling test failure, but final acceptance of items on hand or later produced shall not be made until it is determined that the items meet all the requirements of this specification

\*4 5 2 4 Sampling plan C Unless otherwise specified, five compasses shall be selected at random from each 500 or fraction thereof produced on the contract or order and tested as specified under 4.6.29 for a total of 7,000 hours.

\*4 5.2 4 1 Acceptance and rejection Figure 4 shall be the criteria used to determine whether the equipment will be accepted or rejected. Certified time records shall be maintained of the test time accumulated on the equipment after starting the environmental cycling specified in 4 6 29. In the event a continue-test decision applies after 7,000 hours of testing, the production quantity shall be considered as conditionally acceptable; however, the accumulated time and failures shall be added to the data of the next production quantity for a composite accept-reject decision. If the continue-test condition persists, the data from successive production quantities shall be accumulated until 10 failures or 31,400 hours of testing have occurred at which time an accept-reject decision shall be made. In the event of a reject decision, production units shall be considered unacceptable and deliveries shall be stopped immediately. No more deliveries shall be made until further notice from the procuring activity.

\*4 5 2 4 2 Recording Recording, data handling, and reporting procedures shall be in accordance with MIL-STD-781.

4 5 3 Defects in items already accepted. The investigation of a test failure could indicate that defects exist in items already accepted. If so, the contractor shall fully advise the procuring activity of all defects likely to be found and methods of correcting them.

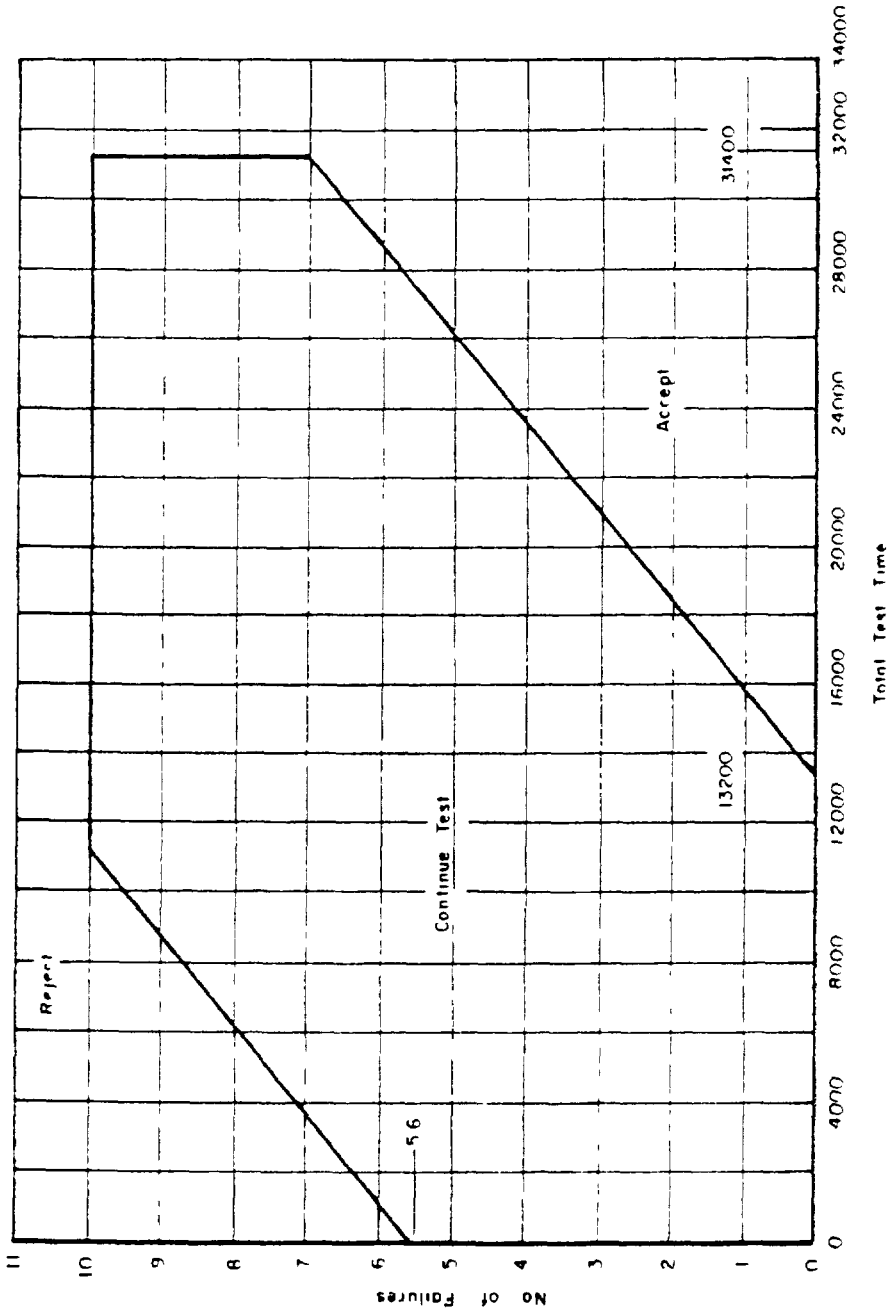
\*4 5 3 1 Corrective action and retest Corrective action and retest shall be required for each failure that can be reasonably attributed to poor manufacture or design practices, or which adversely affects mission completion.

#### 4 6 Test methods

4 6 1 Examination of product The compass shall be visually inspected to determine compliance with the requirements specified herein with respect to materials, design and construction, necessary mechanical measurements, marking, and workmanship.

4 6 1.1 Foreign material inside compass case. The compass shall be held face down and rocked through approximately 40° (20° either side or vertical) at a rate of approximately 1 Hz for 5 seconds. The compass shall then be placed face down for approximately 3 minutes. With the face still down, the compass shall be gently raised over the head and viewed in a light intensity of approximately 48 foot-candles of incident light or 10 foot-lamberts of reflected light, equivalent to two 100-watt incandescent





\*FIGURE 4 Accept - Continue Test - Reject Criteria

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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 line the width of which shall be approximately 0.016 inch.

4.6.1.2 Bubble test: The compass shall be tilted 18° in pitch (dive) and no bubbles shall appear in the compass face. The compass may be gently shaken to loose any bubbles that adhere to the coverglass.

4.6.2 Tilt error: With the compensators removed or set at zero, the compass shall be observed and readings taken at each 30° heading. The compass shall then be tilted 10° in pitch about a horizontal axis. The change in readings at each 30° heading shall not exceed 2°.

4.6.2.1 With the compass tilted 18° in either pitch or bank about a horizontal axis, the card shall be free to revolve on its pivot and all of its letters, numerals, and markings shall be clearly readable from a point 2 feet in front of and level with the center of the compass.

4.6.2.2 At each 30° heading when tilted 18° about a horizontal axis in bank, the reading shall not differ by more than 5° from the reading obtained with the compass in the normal position. At 18° bank, the reading shall be taken at midpoint of the graduations. At level position, the reading point shall be at the bottom of the graduations.

4.6.3 Zero compensation: With the compensator 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 then be turned until the compass reads North. The fixture shall then be set on East and the E-W compensating screw turned until the compass reads East. 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 two and the fixture 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 compensating 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 0.5° as read on the 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 alignment error and shall not exceed ±2°. This test shall be repeated with rated lighting power applied.

4.6.4 Compass error without compensation: This test shall be conducted with the compensator removed from the compass as a unit, and 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 4.6.3.

4.6.4.1 With the test fixture set on North, the compass shall indicate 0° within ±2°. From this position, the fixture shall be turned about its vertical axis, by reference to

an accurate circular scale, to each 30° heading. After allowing for alignment error, the error at any point shall not exceed 1°

4 6 5 Friction error. The compass card shall be deflected 5° from its equilibrium position by use of a small permanent magnet. The magnet shall be withdrawn very slowly allowing the compass card to return towards its equilibrium position. This procedure shall be repeated deflecting the card 5° in the opposite direction. In each case, the card shall return to within 1° of its original position without the compass being vibrated or tapped. The deflecting magnet shall be very slowly removed so that the card will not gain momentum.

4 6 6 Balance The compass shall be held in its normal operating position. The deviation of the card plane from the horizontal, as determined by any suitable method, shall not exceed 1°. As a minimum, readings shall be made at the four cardinal headings.

4 6.7 Early failure The compass shall be subjected to a 1-hour functional reliability test as follows. The compass shall be mounted on a turntable which has been inclined at 10° ±2° to the horizontal and so located that the window faces the outer edge of the turntable. The table shall be turned at a rate of 3-3/4 ±1/2 rpm with the instruments revolving 360° about its vertical axis and 20° about its horizontal axis each revolution. This shall be continued for a period of 1 hour after which the compass shall be subjected to the test specified in 4 6 5.

\*4 6 8 Lighting. Except as specified herein, the lighting system shall be tested in accordance with MIL-L-25467 or MIL-L-27160, as applicable.

\*4.6 8 1 Visual comparison The compass and the prime standard shall be energized at 3.00 ±0.01V and shall appear identical in brightness.

\*4 6.8 2 Color. The AQU-5/A compass and the red lighted prime standard shall be energized with 5 ±0.01V and the AQU-3/A compass and the white lighted prime standard shall be energized with 4.5 ±0.01V for the color test. In each case, the compass and the prime standard shall appear identical in color.

\*4 6 8 3 Before a compass is rejected due to discrepancies detected by visual comparison, it may be subjected to the brightness or color tests specified in MIL-L-25467 or MIL-L-27160, as applicable.

4.6.9 Compensation. With the vertical plane of the mounting surface at right angles to the magnetic meridian and with the E-W compensator set at 0°, the N-W compensator shall be set successively to its maximum positive and maximum negative positions. The maximum card deviations shall then be noted.

4 6.9.1 With the vertical plane of the mounting surface parallel to the magnetic meridian and the N-S compensating system set at 0°, the E-W compensator shall be set successively to its maximum positive and maximum negative positions. The maximum card deviations shall then be noted.

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4 6 9.2 The maximum deviations produced by each compensating system shall be not less than 30° nor more than 40°. Changes in deviation shall be smooth and continuous. Control of the compensating screws shall readily allow changes in compensation of  $\pm 2^\circ$  throughout the compensating range from 0° to maximum.

4 6.9.3 Maximum compensation applied unnaturally (E-W when compass is oriented to North or South and N-S when compass is oriented to East or West) on either heading shall not affect the indication of the other heading by more than 2°. When no adjustment is made, the compensating screw shall be set to 0° compensation.

\*4 6 10 Compass error caused by compensating mechanism Compasses which have been subjected to the test specified in 4 6.4 with the compensators removed shall be subjected to the same test with compensators installed. The compensator shall be set to zero compensation. Changes in compass readings from the first readings obtained during the compass-error test shall not exceed 2° at any heading. This test shall be repeated with rated power applied.

4 6 11 Low temperature operation The compass shall operate satisfactorily when subjected to a temperature of  $-54^\circ\text{C}$  for a period of 4 hours. There shall be no evidence of leakage or damage. The compass need not be subjected to the specified magnetic field during this test.

4 6 12 High temperature operation The compass shall operate satisfactorily when subjected to a temperature of  $71 \pm 2^\circ\text{C}$  for a period of 4 hours. There shall be no evidence of leakage or damage. The compass need not be subjected to the specified magnetic field during this test.

4 6.13 Time of swing With the compensator removed, the card shall be magnetically deflected 30° from its equilibrium position, held long enough for the liquid to come to rest, and then released. The time for the card to pass through 25° toward its equilibrium position shall be observed. The test shall be repeated with the card deflected 30° to the other side of its equilibrium position. The average time of the two readings shall be not less than 1.4 nor more than 1.8 seconds. The position of the compass shall not be changed during this test.

\*4 6 14 Vibration error The compass 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. The heading shall be observed. The compass shall be subjected to vibration in such a manner that a point on the case will describe a circle having a diameter between 0.009 and 0.011 inch at frequencies varying from 5 to 500 Hz. The difference between the card reading before vibration and during vibration shall not exceed 3°.

4 6 15 Damping With the compensator removed, the card shall be magnetically deflected 30° from its equilibrium position, held at this position long enough for the liquid to come to rest, and then released. The overswing past the equilibrium position shall be noted. The test shall be repeated with a deflection of 30° in the opposite

direction. The average of the two shall not exceed 15°. This test and the time-of-swing test may be combined.

4.6.16 Swirl While in its normal upright position at any heading and with the liquid at room temperature, the compass shall be turned through 360° in 1 minute. The compass shall read within 1° of its original heading within 6 seconds after completion of the turn.

4.6.17 Lubber line The compass shall be held in its normal operating position. Deviation of the lubber line from the vertical, as determined by any suitable method, shall not exceed 1°. The compass need not be subjected to the specified magnetic field during this test.

\*4.6.18 Insulation With the lamps removed, a potential of 500V at a frequency of 60 Hz shall be applied between the pins and between pins and the case for a period of 1 minute. There shall be no breakdown of insulation.

4.6.19 Mounting lugs The compass case, with mechanism removed, shall be mounted face downward on the movable head of a suitable testing machine with the face of the case in a horizontal plane so that the mounting lugs will receive no added support. A pin with a head diameter of 9/32 inch maximum shall be inserted through the hole in the mounting lug and attached to a pull strap. A load of 175 pounds shall be applied along the axis toward the front of the case for a period of 1 minute. There shall be no fracture.

4.6.20 Connector installation A 25-inch-pound moment shall be imposed on the connector for a period of 1 minute to determine that it is adequately installed and of such strength that it will not become loosened or damaged in service use. The 25-inch-pound moment shall include that caused by the test rod weight.

4.6.21 Stability with change in magnetic latitude The compass shall meet the test specified in 4.6.6. The compass, in its normal operating position, shall then be subjected to a field of 0.18 oersted horizontal component and zero intensity vertical component. Such a field may be produced by means of a Helmholtz coil. Deviation of the card plane from the horizontal, as determined by any suitable method, shall not exceed 3°.

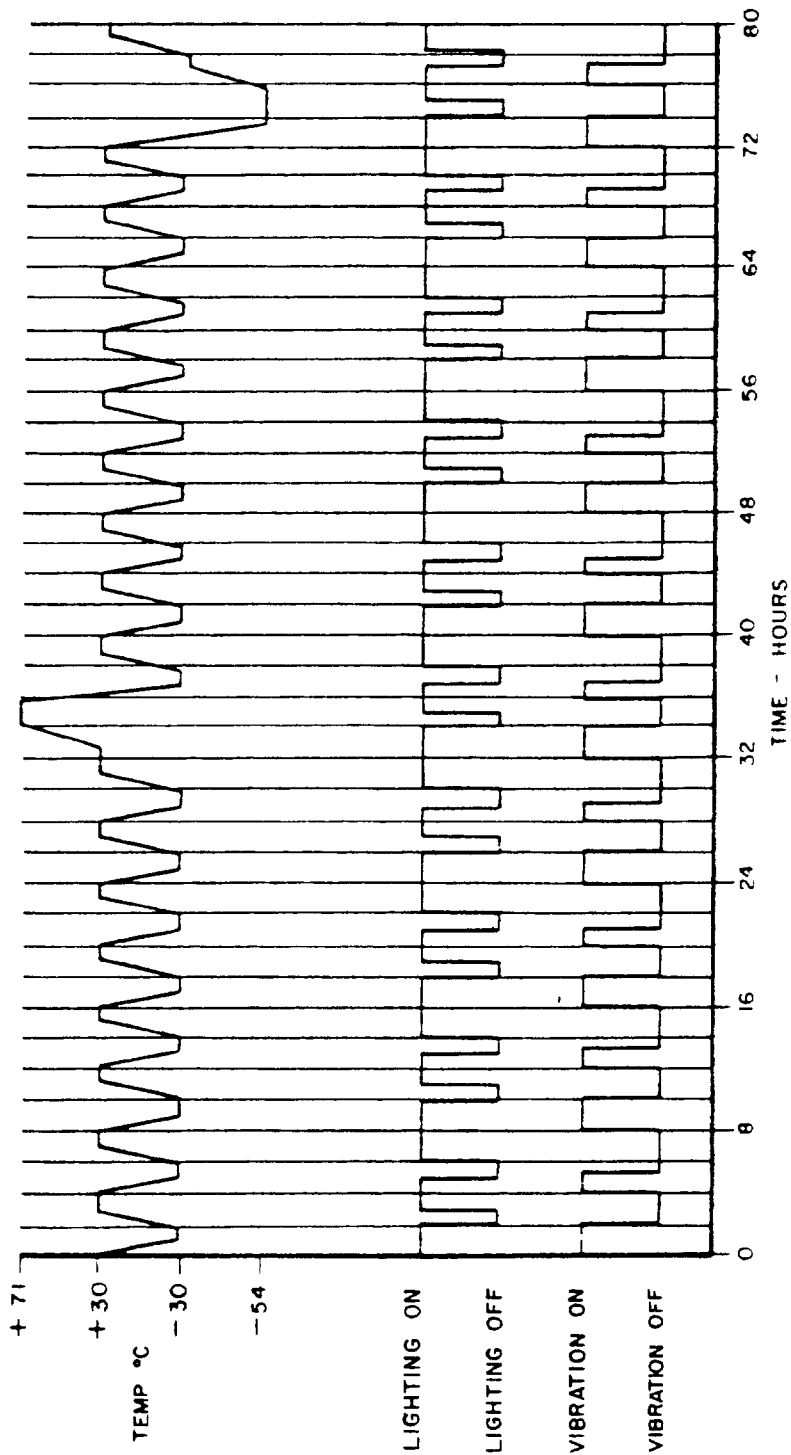
\*4.6.22 Temperature-altitude The compass shall be subjected to a temperature-altitude test in accordance with MIL-STD-810, method 504, class 2, procedure 1, except that the altitude shall be 80,000, in step 5, the stabilized temperature shall be maintained for 4 hours at 71°C, and step 7 shall be omitted. Throughout the test, no bubble larger than 1 inch shall appear in the bowl. In the air-chamber type compass, no bubble shall appear in the normal upright position nor show on the window of the compass up to an 18° tilt angle. Any bubble that might have formed at the specified temperature shall completely disappear after 2 hours at room temperature. The compass need not be subjected to the specified magnetic field during this test.

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- \*4.6.23 Thermal shock The compass shall be immersed alternately in tap water maintained at  $71^{\circ} \pm 5^{\circ}\text{C}$  and  $5^{\circ} \pm 4^{\circ}\text{C}$  for a total of 8 cycles. The length of time for each immersion shall be 30 minutes with not more than 5 seconds elapsing between immersions. No damage to the seal shall occur as a result of this test. Following the immersions, the compass shall be checked for leaks.
- \*4.6.24 Shock The shock test shall be conducted in accordance with method 516, procedures I and III of MIL-STD-810. Following the test specified in procedure I, the compass shall meet the individual tests.
- \*4.6.25 Environmental tests The following environmental tests shall be conducted in accordance with the specified methods of MIL-STD-810. At the option of the procuring activity, these tests may be performed on finished empty cases with all external parts attached as on production units. At the completion of each test, the compass case shall be inspected for any damage that would impair proper compass operation.
- \*4.6.25.1 Humidity The humidity test shall be conducted in accordance with method 507, procedure I.
- \*4.6.25.2 Fungus The fungus test shall be conducted in accordance with method 508, procedure I.
- \*4.6.25.3 Salt fog The salt fog test shall be conducted in accordance with method 509, procedure I, for a period of not less than 168 hours.
- \*4.6.25.4 Dust The compass shall be subjected to a dust test in accordance with method 510, procedure I.
- \*4.6.26 Vibration failure. The compass shall be subjected to a vibration failure test in accordance with method 514, equipment category (b), curve C of MIL-STD-810. At the completion of this test, the compass shall meet the test specified in 4.6.5. No screws or other parts shall become loosened and no leakage shall occur during vibration. The compass need not be subjected to the specified magnetic field during this test.
- \*4.6.27 High temperature exposure The compass shall be placed in the test chamber, the internal temperature raised to  $71^{\circ} \pm 2^{\circ}\text{C}$  and maintained at that temperature for a period of 24 hours. A relative humidity of not more than 15 percent shall be maintained in the test chamber throughout the exposure period. At the conclusion of the exposure period and while still at the high temperature, the compass shall be subjected to the test specified in 4.6.12. The chamber shall be returned to room temperature and the compass soaked at this temperature for a minimum period of 4 hours. It shall then meet the individual tests. There shall be no damage that would adversely affect subsequent operation. If approved by the procuring activity, this test and the high temperature operation test may be combined. The compass need not be subjected to the specified magnetic field during this test.

- \*4.6.28 Low temperature exposure The compass shall be placed in a test chamber maintained at a temperature of  $-62^{\circ}\text{C}$  and a relative humidity of not more than 15 percent for a period of 24 hours. At the end of the 24-hour period, the temperature shall be raised to  $-54^{\circ}\text{C}$  and the compass exposed to this temperature for 4 hours. The compass shall then be subjected to the test specified in 4.6.11. The test chamber shall be returned to room temperature and the compass exposed to this temperature for a minimum of 4 hours after which it shall meet the individual tests. There shall be no damage to the computer that would affect subsequent operation. If approved by the procuring activity, this test may be combined with the low temperature test (4.6.11). The compass need not be subjected to the specified magnetic field during this test.
- \*4.6.29 Reliability The compasses shall be properly connected and placed in test chambers which meet the environmental-cycling conditions shown on figure 5. During this test, the compasses shall be rotated about the vertical axis at a rate of  $3.75 \pm 0.5$  rpm. The on-off lighting operation, vibration, and temperature cycling shall be as shown on figure 5. After each 160-hour cycle of operation, the compasses shall meet the individual tests. Upon completion of this test, or upon reaching an accept decision, the compass shall pass the sampling plan A tests.
- \*4.6.29.1 Temperature variation Temperature variation shall be in accordance with figure 5 and the temperature change shall be no more than  $2^{\circ}\text{C}$  per minute. The periods of testing at  $-71^{\circ}\text{C}$  and  $-54^{\circ}\text{C}$  may be changed to coincide with the work shift. The temperature chamber shall be stabilized at the temperature shown at each 1-hour test point.
- \*4.6.29.2 Vibration During the vibration-on period (approximately 3 hours per each 8-hour period as shown on figure 5) the compasses shall be subjected to vibration along the vertical axis at 20 to 30 Hz at a g level of 0.5g.
- \*4.6.29.3 High altitude-low temperature Every fourth 80-hour cycle, the temperature shall be held constant at  $-35^{\circ}\text{C}$  and the altitude shall be held constant at 50,000 feet.
- \*4.6.29.4 Lighting During the reliability test, the compasses shall be subjected to the life test specified in MIL-L-25467 or MIL-L-27160, as applicable. The power supply to the lighting circuit shall be interrupted for a period of 3 minutes every 57 minutes.
- \*4.6.29.5 Monitoring Monitoring of performance shall be conducted after every other 80-hour cycle or every 160 hours. In case of malfunction, a record of the failure shall be made and the unit repaired. The repairs made shall be recorded and testing shall continue from the point of interruption.
- \*4.6.29.6 Allowances and failures There shall be a 50 percent increase in tolerances for units which have operated for more than 800 hours, and a 100 percent increase in tolerances for units which have operated for more than 2,000 hours. Out-of-tolerance, calibration-type requirements will only be considered as failures if they occur in two successive cycles.

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\*FIGURE 5. Environmental Cycling



\*4.6.29.7 Relevancy criteria. All failures shall be classified as relevant unless approved for exclusion by the procuring activity.

\*4.6.29.8 Test information Sixty days prior to starting this test, the contractor shall submit detailed test information to the procuring activity for approval. This information shall include but not necessarily be limited to

- a. Equipment used in monitoring performance
- b. Periodicity of calibration checks to be made on monitoring equipment
- c. Description of environmental test facilities to be used, including recording facilities, methods of controlling heating, cooling, and pressure facilities, and vibration equipment
- d. Frequency of monitoring

\*4.6.29.9 Test records Throughout this test, the contractor shall maintain adequate test records which shall be prepared in a form suitable for reproduction. As a minimum, the records shall include the following in accordance with MIL-STD-781.

- a. An operation sheet log of failures
- b. Failure report
- c. Equipment repair sheet
- d. Failure tag
- e. Failed-part summary analysis

\*4.6.29.10 Reproducible copies of the data shall be submitted to the procuring activity within 30 days after the completion of each test phase.

\*4.6.29.11 Repair of failed units In the event of a failure during testing, the failed unit shall be repaired and the test continued.

\*4.6.30 Longevity Three of the samples that have been subjected to reliability testing shall continue to be tested as specified under 4.6.29 for a total of 3,000 hours each.

4.7 Inspection of preservation, packaging, and packing The inspection and testing of preservation, packaging, and packing shall be in accordance with section 5.

## 5 PREPARATION FOR DELIVERY

### 5.1 Preservation and packaging

5.1.1 Level A Compasses shall be preserved in accordance with MIL-P-116, method IA8 and packaged one each in a container conforming to PPP-B-566, PPP-B-636, PPP-B-665, or PPP-B-676.

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5.1.2 Level C Compasses shall be provided sufficient protection against physical and mechanical damage to assure safe delivery without degradation of equipment reliability from the supply source to the first receiving activity for immediate use.

5.2 Packing

5.2.1 Level A Compasses packaged in accordance with 5.1.1 shall be packed for shipment in exterior-type shipping containers conforming to PPP-B-636, water-resistant type

5.2.2 Level B Compasses packaged as specified in 5.1.1 shall be packed for shipment in domestic-type exterior shipping containers conforming to PPP-B-636

5.2.3 Level C Packages that require overpacking for acceptance by the carrier shall be packed in exterior-type shipping containers in a manner that will insure safe transportation at the lowest rate to the point of delivery. Containers shall meet the consolidated freight classification rules or regulations of other common carriers as applicable to the mode of transportation

5.3 Physical protection Cushioning, blocking, bracing, bolting, and testing to determine adequacy of the completed package shall be in accordance with the applicable requirements of MIL-STD-794.

5.4 Marking for shipment Marking for shipment shall be in accordance with MIL-STD-129. The nomenclature shall be in accordance with the following, as applicable:

Compass, Magnetic, Mounted \_\_\_\_\_ \*

\*Type designation to be entered by the contractor

## 6 NOTES

\*6.1 Intended use The AQU-5, A and the AQU-5'A compasses covered by this specification are intended for use as the pilot's standby magnetic compass in aircraft equipped with a remote indicating compass to continuously indicate the aircraft heading 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 Type of compass required (see 1.2)
- c When sampling plan B tests will not be conducted
- d When sampling plan C tests will not be conducted

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e. Report of all failures occurring during testing, to be submitted to the procuring activity within 2 working days

f Levels of packaging and packing required (see section 5).

\*6.3 Definitions

\*6.3.1 Failure Where a condition is specified as a requirement, a failure will be considered as any electrical or mechanical condition that fails to comply with the requirements specified herein

\*6.3.2 Discrimination ratio The discrimination ratio is the ratio of the minimum acceptable MTBF to the contractually specified MTBF. In the event that any conflict in definition exists between this specification and any other document, the definition of this specification will govern

\*6.4 Qualification With respect to products requiring qualification, awards will be made only for products which are, at the time set for opening of bids, qualified for inclusion in the applicable Qualified 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 Aeronautical Systems Division, Attn ASNFI-10, Wright-Patterson Air Force Base, Ohio 45433 and information pertaining to qualification of products may be obtained from that activity

6.5 The margins of this specification are marked with an asterisk to indicate where changes (additions, modifications, corrections, deletions) from the previous issue were made. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationship to the last previous issue

Custodian  
Air Force - 11

Preparing activity  
Air Force - 11

Review activity  
Air Force - 71

Project No 6605-F174

SPECIFICATION ANALYSIS SHEET		Form Approved Budget Bureau No 22-R255
<p><b>INSTRUCTIONS</b> This sheet is to be filled out by personnel either Government or contractor involved in the use of the specification in procurement of products for ultimate use by the Department of Defense. This sheet is provided for obtaining information on the use of this specification which will insure that suitable products can be procured with a minimum amount of delay and at the least cost. Comments and the return of this form will be appreciated. Fold on lines on reverse side, staple in corner, and send to preparing activity. Comments and suggestions submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or serve to amend contractual requirements.</p>		
SPECIFICATION		
ORGANIZATION		
CITY AND STATE	CONTRACT NUMBER	
<p>MATERIAL PROCURED UNDER A</p> <p><input type="checkbox"/> DIRECT GOVERNMENT CONTRACT      <input type="checkbox"/> SUBCONTRACT</p>		
<p>HAS ANY PART OF THE SPECIFICATION CREATED PROBLEMS OR REQUIRED INTERPRETATION IN PROCUREMENT USE?</p> <p>A. GIVE PARAGRAPH NUMBER AND WORDING</p>		
<p>B. RECOMMENDATIONS FOR CORRECTING THE DEFICIENCIES</p>		
<p>C. COMMENTS ON ANY SPECIFICATION REQUIREMENT CONSIDERED TOO RIGID</p>		
<p>D. IS THE SPECIFICATION RESTRICTIVE?</p> <p><input type="checkbox"/> YES      <input type="checkbox"/> NO (If "yes" in what way?)</p>		
<p>E. REMARKS (Attach any pertinent data which may be of use in improving this specification. If there are additional papers attach to form and place both in an envelope addressed to preparing activity.)</p>		
SUBMITTED BY (Printed or typed name and activity - Optional)		DATE

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