

MIL-A-13338E(AR)
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SUPERSEDING
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MILITARY SPECIFICATION

AIMING CIRCLE: M2 AND M2A2

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 This specification covers the Aiming Circle: M2 and M2A2.

2. APPLICABLE DOCUMENTS

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

SPECIFICATIONS

MILITARY

MIL-L-10470	-	Lights, Instrument: Fire Control Equipment
MIL-O-13830	-	Optical Components for Fire Control Instruments; General Specification Governing the Manufacture, Assembly, and Inspection of
MIL-F-13926	-	Fire Control Materiel: General Specification Governing the Manufacture and Inspection of
MIL-P-14232	-	Parts, Equipment and Tools for Ordnance Materiel, Packaging of

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, US Army Armament Research and Development Command, Attn. DRDAR-QA, Dover, New Jersey 07801 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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- MIL-I-45607 - Inspection Equipment, Supply and Maintenance of
- MIL-T-63443 - Telescope, Elbow Assembly: 8211640

STANDARDS

MILITARY

- MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes
- MIL-STD-109 - Quality Assurance Terms and Definitions
- MIL-STD-810 - Environmental Test Methods

DRAWINGS

US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND (ARRADCOM)

- A5800554 - Aiming Circle: M2 W/Equipment
- F8211637 - Aiming Circle: M2
- A5911272 - Aiming Circle: M2A2 W/Equipment
- F11834483 - Aiming Circle: M2A2
- IEL 11834483 - List of Inspection Documents for Aiming Circle: M2A2

PACKAGING DATA SHEET

- MIL-P-14232/P5800554 - Packaging of Aiming Circle: M2 W/E
- MIL-P-14232/P5911272 - Packaging of Aiming Circle: M2A2 W/E

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

3. REQUIREMENTS

3.1 General Specification. The contractor shall be responsible for adherence to the following requirements of MIL-F-13926:

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- (a) Order of precedence
- (b) Dimensions and tolerances
- (c) Inorganic protective surface finishes
- (d) Commercial quality
- (e) Part identification and marking
- (f) Workmanship

3.2 Aiming Circle: M2 and M2A2.

3.2.1 Fabrication. The M2 Aiming Circle shall be manufactured in accordance with Drawing F8211637 and drawings pertaining thereto. The M2A2 Aiming Circle shall be manufactured in accordance with Drawing F11834483 and drawings pertaining thereto.

3.2.1.1 First Article Testing. Requirements for the submission of first article samples by the contractor for testing shall be as specified in the contract.

3.2.2 Environmental Service Conditions.

3.2.2.1 Storage Temperatures. The Aiming Circle shall show no evidence of failure, such as cement separation, glass breakage, or other physical failure, after having been exposed to and thermally stabilized at ambient temperatures of -80° and $+160^{\circ}$ Fahrenheit (F).

3.2.2.2 Extreme Operating Temperatures. The Aiming Circle shall meet the requirements of 3.2.3.7 and 3.2.3.14 and the applicable requirements of 3.2.3.15 while exposed to and thermally stabilized at ambient temperatures of -40° and $+150^{\circ}$ F. The base plate cover and lower azimuth (orienting) knob covers shall be operable at these temperatures.

3.2.2.3 Standard Ambient Temperature. Subsequent to the requirement of 3.2.2.1, the Aiming Circle shall meet the requirements of 3.2.2.4 to 3.2.3.16 inclusive at a standard ambient temperature between $+60^{\circ}$ and $+90^{\circ}$ F unless otherwise specified.

3.2.2.4 Vibration. The Aiming Circle shall withstand a vibration of 30 ± 5 cycles per second (CPS) frequency with an amplitude of $1/16$ inch ($1/8$ inch maximum excursion) for a period of 5 minutes \pm 15 seconds. Subsequent to vibration, there shall be no visible damage, cement separation, or loosening of assembled parts, and the Aiming Circle shall meet the requirements of 3.2.2.5 to 3.2.3.16 inclusive.

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3.2.2.5 Cleanliness.

3.2.2.5.1 Telescope. Subsequent to vibration, the Telescope shall meet the cleanliness requirement of MIL-O-13830, and there shall be no more than 2 particles of dirt visible on the surfaces of the reticle. Each particle shall not be in excess of an area equivalent to a size 5 dig. There shall be no dirt on other surfaces which interferes with observation or adversely affects image quality.

3.2.2.5.2 Magnifier. Subsequent to vibration, the Magnifier shall meet the cleanliness requirement of MIL-O-13830. There shall be no more than 2 particles of dirt visible on the surfaces of the Compass Magnifier Reticle, and each particle shall not be in excess of an area equivalent to a size 5 dig. There shall be no dirt on other surfaces which interferes with observation or adversely affects image quality.

3.2.2.6 Sealing.

3.2.2.6.1 Telescope. The Telescope shall show no evidence of leakage in excess of 0.2 psig when subjected to an internal pressure of 5.0 ± 0.1 psig for a period of 2 hours using dry nitrogen having a dew point at least as low as -25°F .

3.2.2.6.2 Compass Compartment. The Compass Compartment shall show no evidence of leakage in excess of 0.2 psig when subjected to an internal pressure of 5.0 ± 0.1 psig for a period of 2 hours using dry nitrogen having a dew point at least as low as -25°F .

3.2.2.6.3 Complete Instrument (Riveted Cover Secured). The Aiming Circle, with riveted cover secured, (the catches shall securely engage the underside of the Aiming Circle base plate, and the bottom edge of the cover shall form an airtight joint with the base gasket) shall show no evidence of leakage in excess of 0.2 psig when subjected to an internal pressure of 5.0 ± 0.1 psig for a period of 2 hours using dry nitrogen having a dew point at least as low as -25°F .

3.2.2.7 Shock. The Aiming Circle, with the needle locked and the riveted cover secured (see 3.3.2), shall be dropped once in each of the following positions from a height of 3 feet onto a solid wood floor covered with 4 inches of 40 grit, kiln dried sand.

- (a) Vertical (normal mounting position).
- (b) Approximately 45 degrees left from vertical position

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(c) Approximately 45 degrees right from vertical position.

After these drops, the instrument shall show no damage and shall meet all the requirements of this specification pertaining to the Aiming Circle.

3.2.3 Performance.

3.2.3.1 Scale Settings.

3.2.3.1.1 Azimuth Setting. With the axes of the two azimuth worms approximately parallel to each other and on the same side of the vertical axis of the instrument, and with the index line set to coincide with the zero graduation line on the azimuth scale, the azimuth micrometer shall indicate zero.

3.2.3.1.2 Elevation Setting. With the telescope level, as indicated by the tubular level vial, the zero graduations on both the telescope elevation scale and the micrometer knob scale shall be in coincidence with their respective index lines within 1/4 line width.

3.2.3.2 Leveling. With the line of sight of the telescope describing a horizontal plane within 0.1 mil as it is rotated 360 degrees in azimuth by means of the upper azimuth knob, the following requirements shall be met:

3.2.3.2.1 Tubular Level Vial Bubbles. The Tubular level vial bubbles shall be central with respect to the level vial graduations within 0.15 mil and shall agree with each other within 0.15 mil.

3.2.3.2.2 Circular Level Vial Bubble. Eccentricity of the bubble with respect to the red circle on the face of the circular level vial, shall not exceed one-half the width of the line forming the red circle.

3.2.3.3 With the horizontal position established as in 3.2.3.2, the following requirements shall be met:

3.2.3.3.1 Orienting Mechanism. The line of sight shall not deviate from the horizontal by more than 0.3 mil when rotated 360 degrees in azimuth by means of the orienting (lower azimuth) knob.

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3.2.3.3.2 Parallelism of Reticle and Image. The vertical reticle line of the telescope shall be parallel to the image of a plumb line within 0.6 mil when measured adjacent to the "80" graduation, with the reticle line being coincident with the plumb line at the other "80" graduation.

3.2.3.3.3 Alignment. When the compass reticle is centered on the index of the free compass needle, the line of sight of the telescope shall be parallel within 0.50 mil to the north-south axis of the earth's magnetic field affecting the needle.

3.2.3.3.4 Plumb Travel. The line of sight shall not deviate from a plumb line by more than 0.25 mil when the telescope is actuated through 430 mils depression to 830 mils elevation movement at any azimuth setting, starting with the reticle line and plumb line in coincidence at zero elevation. An additional 0.15 mil of plumb travel error (0.4 mil total) shall be permissible provided that the accumulated total horizontal error as specified in 3.2.3.6 is not exceeded thereby. An additional plumb travel error of .6 mils is permitted for the M2A2 in the elevation range from 830 to 1100 mils.

3.2.3.3.5 Elevation Limits. The limits permitted by the stop rings shall allow at least 830 mils movement of the telescope above the horizontal for the M2 Aiming Circle and at least 1100 mils movement of the telescope above the horizontal for the M2A2 Aiming Circle and 430 mils below the horizontal and shall prevent the telescope from striking the compass box cover.

3.2.3.3.6 Circle Error (Azimuth). Angular measurements from a zero position, as read on the azimuth scales, shall indicate true azimuth rotation of the telescope line of sight within 0.60 mil, excluding backlash.

3.2.3.3.7 Elevation Error. Angular measurements from a zero position as read on the elevation scales shall indicate true vertical deviation of the telescope line of sight from a horizontal plane within 0.60 mil, excluding backlash in the range from -430 mils to +830 mils, and within 1.00 mils, excluding backlash, from +830 mils to +1100 mils.

3.2.3.3.8 Backlash. Backlash in the Aiming Circle shall not exceed the following tolerances:

Elevating mechanism	0.60 mil
Upper azimuth mechanism	0.30 mil
Orienting mechanism	0.50 mil

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3.2.3.4 Lift. In reversing the azimuth motion of the telescope by means of the upper and the lower azimuth worm knobs, the displacement between the line of sight and a horizontal line shall not exceed 0.3 mil.

3.2.3.5 Side Play. In reversing the elevation motion by means of the elevation knob, the displacement of the line of sight from coincidence with a plumb line shall not exceed 0.20 mil. An additional 0.10 mil of side play error (0.30 mil total) shall be permissible provided the accumulated horizontal error as specified in 3.2.3.6 is not exceeded thereby.

3.2.3.6 Total Horizontal Error. The arithmetic sum of the maximum recorded plumb travel error (3.2.3.3.4), azimuth circle error (3.2.3.3.6), and side play error (3.2.3.5) shall not exceed 1.0 mil under any condition.

3.2.3.7 Compass.

3.2.3.7.1 Magnetic Needle. The needle shall be balanced so that the needle index is visually parallel to the compass reticle lines. The magnetic needle mechanism shall maintain the south end of the needle in a vertical plane within the two short reticle lines of the compass reticle. The needle shall function when the instrument is 3 degrees out of level.

NOTE: Magnetic Storms. Requirements of 3.2.3.7.2 and 3.2.3.7.3 shall be met after a determination has been made to insure that no magnetic storms exist, such as those created by sun spots, which may adversely affect function of the compass needle.

3.2.3.7.2 Repeatability. The magnetic needle index line, when set at one edge of a reticle line in the magnetic needle magnifier, shall return to the same position within 0.5 mil (the approximate width of a reticle line) after the needle has been subjected to maximum magnetic displacement three times in both directions.

3.2.3.7.3 Half Period. In areas where the horizontal intensity of the earth's magnetic field is not lower than 0.12 oersteds, the average half period shall be 2.5 seconds or less for a minimum of six successive half periods when the needle is deflected a minimum of 8 degrees. The half period is defined as the time interval between successive transits of the south end of the needle through its point of equilibrium.

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3.2.3.8 Magnifier Assembly Parallax. The magnetic needle magnifier assembly parallax shall not exceed 1.0 mil (1 reticle line width is equivalent to approximately 0.50 mil).

3.2.3.9 Magnetic Needle Magnifier. The magnetic needle magnifier shall focus sharply at the etched surface on the magnetic needle within 0 to -0.5 diopter.

3.2.3.10 Resolution. The resolving power on the telescope optical axis shall be 14 seconds of arc or less.

3.2.3.11 Eyeiece Focus. The eyepiece focus for the telescope shall be fixed between the limits of -0.75 and -1.0 diopter.

3.2.3.12 Open Sight. The line of sight of the open sight shall be parallel to the line of sight of the telescope within 10 mils.

3.2.3.13 Parallax in Telescope. Parallax between reticle and target image shall be nominally zero at 50 yards and shall not exceed 0.30 mil over a range of 30 to 150 yards.

3.2.3.14 Magnetic Needle, Clamp, and Release Mechanism. The clamping mechanism shall function to hold the magnetic needle firmly against the compass box cover when the lever is vertical. When rotated clockwise to the horizontal position, the lever must detent and shall cause the needle to swing free. When rotated counterclockwise to the furthest position, the lever shall free the needle while under finger pressure. When released, spring action shall return the lever to the vertical position, causing the needle to be held firmly against the compass box cover.

3.2.3.15 Torque. Running torque in ounce-inches on all knobs shall be within the limits specified below:

	+60° to +90°F		-40°F		+150°F	
	<u>Max</u>	<u>Min</u>	<u>Max</u>	<u>Min</u>	<u>Max</u>	<u>Min</u>
Elevation knob	28	7	80	20	80	7
Upper azimuth knob	36	10	96	20	96	10
Orienting azimuth knobs	48	10	96	32	96	10
Leveling knobs	68	32	96	32	108	32

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3.2.3.16 Illumination. The Aiming Circle shall meet the "Illuminated reticles" requirement of MIL-O-13830. With the telescope reticle illuminated, the reticle markings shall appear clearly defined when observed in a darkened area.

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, the supplier may utilize his own facilities or any commercial laboratory acceptable to 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.

4.1.1 General Provisions. The component and subassembly inspection requirements of MIL-F-13926 form a part of the Quality Assurance Provisions of this specification. Definitions of inspection terms shall be as listed in MIL-STD-109.

4.2 First Article (Initial Production) Approval. The requirement for first article approval and the responsibility (Government or Contractor) for first article testing shall be as specified in the contract. The sample for first article approval tests shall consist of (2) Aiming Circles plus (3) each of all items covered by SQAP. The sample shall be manufactured in the same manner, using the same materials, equipment, processes, and procedures, as used in regular production. All parts and materials, including packaging and packing, shall be obtained from the same source of supply as used in regular production.

4.2.2 Contractor Testing. When the contractor is responsible for conducting first article approval tests, the sample shall be inspected by the contractor for all the requirements of the contract. The sample and a record of this inspection, including certificates of conformance for materials, shall be submitted to the Government for approval. The Government reserves the right to witness the contractor's inspection.

4.3 Inspection Provisions.

4.3.1 Submission of Product. Unless otherwise specified by the Contracting Officer, inspection lot size, lot formation and presentation of lots shall be in accordance with "Submission of Product" provisions of MIL-STD-105.

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4.3.2 Examination and Tests. Components and subassemblies shall be inspected in accordance with the inspection provisions contained in Supplementary Quality Assurance Provisions (SQAP) listed in the Technical Data Package (TDP). In the absence of SQAP's, the applicable Quality Assurance Provisions of MIL-F-13926 shall apply. Examinations and tests related to Section 3 herein shall be performed on a single defect (individual characteristic) basis in accordance with MIL-STD-105, and the sampling plans specified in Tables I, II, III, and IV herein. Examinations and tests for Packaging, Packing, and Marking shall be in accordance with MIL-P-14232 and Section 5 herein. The tabulated classification of defects shall constitute the minimum inspection to be performed by the supplier prior to Government acceptance or rejection by lot.

TABLE I. Classification of Defects

<u>Class</u>	<u>Characteristic</u>	<u>Requirement</u>	<u>Test Procedure</u>
<u>Critical:</u>	<u>None</u>		
<u>Major:</u>	<u>AQL 0.65% Defective</u>		
101.	Vibration	3.2.2.4	4.6.3
102.	Cleanliness of telescope	3.2.2.5.1	4.6.4
103.	Cleanliness of magnifier	3.2.2.5.2	4.6.4
104.	Azimuth scale setting	3.2.3.1.1	4.6.7
105.	Elevation scale setting	3.2.3.1.2	4.6.8
106.	Centrality, tubular level vial bubbles	3.2.3.2.1	4.6.10
107.	Eccentricity, circular level vial bubble	3.2.3.2.2	4.6.10
108.	Eye-piece focus	3.2.3.11	4.6.9
109.	Orienting mechanism	3.2.3.3.1	4.6.11
110.	Resolution	3.2.3.10	4.6.25
111.	Parallelism of reticle and image	3.2.3.3.2	4.6.12
112.	Plumb travel	3.2.3.3.4	4.6.13
113.	Elevation limits	3.2.3.3.5	4.6.14
114.	Circle error (azimuth)	3.2.3.3.6	4.6.15
115.	Elevation error	3.2.3.3.7	4.6.16
116.	Backlash-elevating mechanism	3.2.3.3.8	4.6.17.1
117.	Backlash-upper azimuth mechanism	3.2.3.3.8	4.6.17.2
118.	Backlash-orienting mechanism	3.2.3.3.8	4.6.17.3
119.	Lift	3.2.3.4	4.6.19
120.	Side play	3.2.3.5	4.6.20
121.	Total horizontal error	3.2.3.6	4.6.21

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TABLE I. Classification of Defects, Cont'd

<u>Class</u>	<u>Characteristic</u>	<u>Requirement</u>	<u>Test Procedure</u>
122.	Magnetic needle	3.2.3.7.1	4.6.22.1
123.	Half period	3.2.3.7.3	4.6.22.3
124.	Magnifier assembly parallax	3.2.3.8	4.6.23
125.	Magnetic needle magnifier	3.2.3.9	4.6.24
126.	Open sight	3.2.3.12	4.6.26
127.	Parallax-telescope	3.2.3.13	4.6.27
128.	Magnetic needle, clamp, and release mechanism	3.2.3.14	4.6.28
129.	Illumination	3.2.3.16	4.6.30
<u>Minor: AQL 1.0% Defective</u>			
201.	Torque	3.2.3.15	4.6.29

NOTE: The tests of Table I shall be conducted at standard ambient temperatures (60° to 90°F).

4.3.3 Acceptance and Rejection. Rejected lots shall be screened for all defective characteristics. Removal or correction of defective units and resubmittance of rejected lots shall be in accordance with "Acceptance and Rejection" as specified in MIL-STD-105.

4.4 Special Sampling.

4.4.1 General. One each Aiming Circle, cover (riveted), tripod, instrument light, back plate (riveted), lamp holder and remover, plumb bob assembly, and cover (canvas) shall be selected at random as a special sampling from each 100 produced. The sample shall meet the requirements and tests in Table II.

TABLE II

<u>No.</u>	<u>Characteristic</u>	<u>Requirement</u>	<u>Test Procedure</u>
301.	Fabrication	3.2.1	Applicable drawings, MIL-L-10470, Visual
302.	General specification	3.1	MIL-F-13926, Visual

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4.4.2 Environmental. Three Aiming Circles, covers (riveted), tripods, and back plates (riveted) shall be selected at random as samples from each 50 produced, or from each month's production, whichever occurs first. Each sample shall have met the requirements and tests in Tables I and III and shall then meet the requirements and tests in Table III.

TABLE III

<u>No.</u>	<u>Characteristic</u>	<u>Requirement</u>	<u>Test Procedure</u>
303.	Operating temperatures, base plate cover, lower azimuth knob covers, and compass (-40° and +150°F)	3.2.2.2	4.6.2, 4.6.22.1 through 4.6.22.3
304.	Operating temperatures, magnetic needle, clamp, and release mechanism (-40° and +150°F)	3.2.3.14	4.6.28
305.	Operating temperatures, knobs torque (-40° and +150°F)	3.2.3.15	4.6.29
306.	Storage temperatures, Aiming Circle, (-80° and +160°F)	3.2.2.1	4.6.1
307.	Sealing, telescope (60° to 90°F)	3.2.2.6.1	4.6.5.1
308.	Sealing, compass compartment (60° to 90°F)	3.2.2.6.2	4.6.5.1
309.	Sealing, complete instrument (60° to 90°F)	3.2.2.6.3,	4.6.5.1
310.	Shock (60° to 90°F)	3.2.2.7	4.6.6

TABLE IV.
(100% INSPECTION)

<u>No.</u>	<u>Characteristic</u>	<u>Requirement</u>	<u>Test Procedure</u>
401.	Alignment	3.2.3.3.3	4.6.18
402.	Repeatability (60° to 90°F)	3.2.3.7.2	4.6.22.2

4.4.3 Failure of Sample. Should any one item of a special sampling fail to meet the specified test requirements, acceptance of the product shall be suspended by the Government until necessary corrections have been made by the contractor and resubmitted samples have been approved (see 4.3.3)

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4.5 Inspection Equipment. Except as otherwise provided for by the contract, the contractor shall supply and maintain inspection equipment in accordance with the applicable requirements of MIL-I-45607.

4.5.1 Government Furnished Inspection Equipment. Where the contract provides for Government furnished test equipment, supply and maintenance of test equipment shall be in accordance with the applicable requirements specified in MIL-I-45607.

4.5.2 Contractor Furnished Inspection Equipment.

4.5.2.1 Government Design. All inspection equipment specified by drawing number in specifications or SQAP's forming a part of the contract shall be supplied by the contractor in accordance with technical data included in the Technical Data Package list.

4.5.2.2 Contractor Design. The contractor shall design and supply inspection equipment compatible with the "Test Methods and Procedures" specified in 4.6 of this specification and with the Component Inspection Procedures specified in "Examination" and "Test facilities" requirements of MIL-F-13926. Since tolerance of test equipment is normally considered to be within 10% of the product tolerance for which it is intended, this inherent error in the test equipment design must be considered as part of the prescribed product tolerance limit. Thus, concept, construction, materials, dimensions and tolerances used in the design of test equipment shall be so selected and controlled as to insure that the test equipment will reliably indicate acceptability of a product which does not exceed 90% of the prescribed tolerance limit, and permit positive rejection when non-conforming. Construction shall be such as to facilitate routine calibration of test equipment.

4.6 Test Methods and Procedures.

4.6.1 Storage Temperatures. The Aiming Circle shall be exposed to the temperatures specified in 3.2.2.1, utilizing testing equipment conforming with the "Test facilities" requirements of MIL-STD-810. In the performance of this test, the temperatures shall be changed gradually to avoid thermal shock. After temperature stabilization at -80° and $+160^{\circ}\text{F}$, the Aiming Circle shall be exposed to each specified temperature for a minimum of 5 hours. Subsequent to being exposed to the

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above conditions, and upon return to the standard ambient temperature of 3.2.2.3, the Aiming Circle shall be subjected to a visual and tactile examination to assure that there is no evidence of mechanical and optical failure, cement separation, or deterioration. The unit shall then be tested in accordance with 4.6.3 through 4.6.30 to determine compliance with 3.2.2.3.

4.6.2 Extreme Operating Temperatures. The Aiming Circle shall be exposed to the temperature conditions indicated in 3.2.2.2, employing the test facilities used for the temperature test in 4.6.1. In the performance of this test, the temperatures shall be changed gradually to avoid thermal shock. After temperature stabilization at -40°F and $+150^{\circ}\text{F}$, the temperature shall be maintained constant for a minimum of 5 hours for each condition. At the end of each time period and while still at the temperature extreme, the base plate cover and the lower azimuth knob covers of the Aiming Circle shall be subjected to a tactile examination to assure that the covers will operate freely and will hold in both their open and closed positions. The unit shall then be tested in accordance with 4.6.22, 4.6.28, and 4.6.29 to determine operability in compliance with 3.2.2.2.

4.6.3 Vibration. The Aiming Circle, with the magnetic needle in the locked position, shall be subjected to the vibration test utilizing standard vibrating equipment capable of meeting the conditions of 3.2.2.4. The accuracy of the applicable test equipment and test equipment measurements shall be in accordance with "Test facilities" requirements of MIL-F-13926. The Aiming Circle shall be mounted in its normal operating position on the vibrating table by means of an adapter. The Aiming Circle shall be vibrated in a vertical plane with the motion and frequency applied for the time period specified. At the conclusion of this vibration, the Aiming Circle shall be subjected to a visual and tactile examination for damage such as bent or broken parts, glass chips, fractures, foreign matter, and cement separation; and to a functional examination of moving parts for undue irregularities of movement, friction, or looseness. Any one of the aforementioned defects shall be cause to consider an Aiming Circle defective unless separate defects-per-hundred type sampling plans are established or approved by the Government as part of the supplier's inspection system. Aiming Circles that have passed the above examinations shall be subjected to the tests of 4.6.4 to 4.6.30 inclusive, in compliance with 3.2.2.4.

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4.6.4 Cleanliness. The optical surfaces of the telescope and the magnifier shall be inspected for cleanliness in accordance with MIL-O-13830. The telescope reticle and the magnifier reticle shall not contain particles of dirt in excess of the amount specified in 3.2.2.5.1 and 3.2.2.5.2. Area inspection of dirt particles shall be accomplished by means of a Scratch and Dig Standard conforming to Drawing C7641866 for a comparison of the area of the dirt particles with the dig size of the standard. The telescope and magnifier shall conform to their respective cleanliness requirement. This test shall be performed subsequent to vibration.

4.6.5 Sealing.

4.6.5.1 Telescope and Compass Compartment. Sealing tests for the telescope (3.2.2.6.1), compass compartment (3.2.2.6.2), and the complete instrument (3.2.2.6.3), shall be performed utilizing special testing equipment conforming to the Two Station-Pressure Tester, Drawing F8565556, wherein a special hose adapter to pressurize the telescope and compass compartment will be required. The procedure for the internal pressure test described in the set-up and operating instructions on Sheet 1 of Drawing F8565556 shall apply. The telescope, compass compartment, and the complete instrument, shall each be pressurized with a dry nitrogen gas to the required pressure and maintained for the time specified. Leakage shall not be evident within the time period specified for sealing.

4.6.6 Shock (Complete Instrument with Cover Secured). The instrument with the compass needle and cover secured, shall be subjected to the shock conditions specified in 3.2.2.7. After each drop, the complete instrument shall be subjected to a visual and tactile examination to determine that there is no evidence of damage. At the conclusion of this testing, the Aiming Circle shall then be subjected to and comply with the requirements specified in 3.2.2.7.

4.6.7 Azimuth Scale Setting. Inspection shall be accomplished utilizing special testing equipment. The test equipment shall consist of the devices depicted on Drawing F7681321, Final Test Instruction Sheet and List of Drawings. Mount the Aiming Circle on the special testing equipment in accordance with the set-up instructions described on Drawing F7681321. Azimuth scale setting is a visual test that shall be made to verify the zero reading of the micrometer with the requirements of 3.2.3.1.1.

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4.6.8 Elevation Scale Setting. The Aiming Circle shall be mounted on the special testing equipment in accordance with the set-up instructions, Drawing F7681321. Elevation scale setting is a visual test which shall be made to check the elevation scale and micrometer knob scale with their respective indices to conform with 3.2.3.1.2.

4.6.9 Eyepiece Focus. The eyepiece focus test shall be performed with the aid of a dioptometer conforming to the Dioptometer, Drawing F7680631. The dioptometer shall be adjusted by setting the slide scale index to zero, and the eyepiece of the dioptometer shall be adjusted for the best focus on the dioptometer reticle. Place the dioptometer at the eyepiece of the telescope on the Aiming Circle. Adjust the dioptometer, by movement of the dioptometer tube, until the telescope reticle appears in sharp focus. The diopter scale on the tube of the dioptometer shall indicate between the -0.75 ($3/4$) and -1.0 diopter to conform with 3.2.3.11.

4.6.10 Leveling. When the Aiming Circle is mounted in accordance with the set-up instructions, Drawing F7681321, and with the line of sight describing a horizontal plane as required in 3.2.3.2, the tubular level vial bubbles and circular level vial bubble of the instrument shall meet the requirements of 3.2.3.2.1 and 3.2.3.2.2 when the instrument is rotated through an entire excursion of 360 degrees.

4.6.11 Orienting Mechanism. The Aiming Circle shall be inspected for compliance with 3.2.3.3.1 by taking readings of at least eight random settings, from the position established in 4.6.10, throughout the 6400 mils of travel in azimuth. Counter-rotate the Aiming Circle by means of the lower azimuth knob and the index table "B" of the special testing equipment. Observe the horizontal target zero through the telescope for deviation from zero on collimator "G" of the special testing equipment.

4.6.12 Parallelism of Reticle and Image. With the Aiming Circle in the level position at zero elevation, proceed to make the check by sighting through the telescope, coinciding one end of the telescope's vertical reticle line with the image of a vertical target line when the setting of the "80" graduation of the elevation graduation scale is aligned with the index. Then observe coincidence at the opposite end of the reticle line. The vertical reticle line of the telescope shall not deviate from the image of the vertical target line by more than the

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limit specified in 3.2.3.3.2 as measured on the calibrated target. Deviation can be measured with the index table vernier scale "R" of the special testing equipment.

4.6.13 Plumb Travel. With the vertical line of the telescope reticle superimposed on a plumb line, the line of sight shall track the plumb line through elevation and depression as directed and within the limit specified in 3.2.3.3.4. Movement of the vertical line of sight is accomplished with the elevation knob. Deviation can be measured with the index table vernier scale "R" of the special testing equipment, and shall be noted.

4.6.14 Elevation Limits. Coincident with above test, bring the telescope line of sight, scales, and micrometers to zero. Rotate the elevation micrometer knob to the limit above and below the horizontal permitted by the stop rings. The stop rings should prevent the Aiming Circle telescope from striking the housing cover in the depressed position. Observe the limit of movement, pertinent to the requirements of 3.2.3.3.5, by means of the elevation marks on a target calculated in accordance with the target formulas described in the set-up instruction sheet, Drawing F7681321.

4.6.15 Circle Error (Azimuth). At least eight random settings throughout the 6400 mils of rotation shall be taken with the Aiming Circle positioned in the special testing equipment and leveled. Set the upper azimuth knob to zero by clockwise rotation of the Aiming Circle. Index Table "B" of the special testing equipment shall be set to zero. The line of sight of the telescope shall be directed to center on the collimator reticle by means of the lower azimuth knob. All scales, and micrometers of the Aiming Circle will set to zero. Offset the index table an amount equal to a whole mil in a clockwise direction. Rotate the upper azimuth knob to the same whole mil mark on the micrometer with the Aiming Circle revolving in a counterclockwise direction, using the microscope micrometer "W" to align the Aiming Circle's upper azimuth index and micrometer scale graduation. Azimuth error can be read by observing the amount of movement required, in the index table micrometer scale "R", to recenter the telescope reticle with the collimator reticle. Note the reading. Continue to offset the test fixture an amount equal to a whole mil at a time, and recentering the telescope reticle back on the collimator reticle, until the fixture is back on zero. At each setting, the reading shall be noted. Error in any reading shall not exceed the limit specified in 3.2.3.3.6.

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4.6.16 Elevation Error. With the Aiming Circle positioned in a horizontal plane in coincidence with target zero, check elevation error by setting mil readings on the elevation micrometer corresponding to elevation target stops. Zero should be set with deflection or elevation of the line of sight opposed to the direction of motion required by the target in order to include backlash. Any deviation of the telescope line of sight from the horizontal zero shall not exceed the limit specified in 3.2.3.3.7. Readings shall be taken in increments of 200 mils above and below the horizontal.

4.6.17 Backlash.

4.6.17.1 Elevating Mechanism. Backlash of the elevation mechanism is tested by measuring angles as indicated in 4.6.16. Adjust the instrument's line of sight so that its horizontal reticle line is superimposed on the horizontal target line. Elevate the line of sight by rotating the elevation micrometer knob until a selected point on the target is reached. Note reading of the elevation micrometer scale. Continue rotation in the same direction to a stop beyond this selected point on the target, and then reverse the direction of rotation until the line of sight is superimposed on the same selected point on the target without overtravel. Note reading on the micrometer scale. The difference of the readings is the amount of backlash. Backlash for the mechanism shall not exceed the tolerance specified in 3.2.3.3.8.

4.6.17.2 Upper Azimuth Mechanism. With the Aiming Circle set up in the special testing equipment as in the above tests, adjust the instrument's line of sight so that its vertical reticle line is superimposed on the vertical target line. Rotate the azimuth knob about 600 mils away from the vertical target line and then rotate the knob in the opposite direction until the vertical reticle line of the telescope is again superimposed on the vertical target line. Note the reading of the azimuth micrometer scale. Continue rotating the Aiming Circle in the same direction, about 300 mils, and then reverse the direction of rotation until the vertical reticle line of the telescope is superimposed on the same vertical target line without overtravel. Again note the reading of the micrometer scale. The difference of the two readings is the total amount of backlash. Backlash for the mechanism shall not exceed the tolerance specified in 3.2.3.3.8.

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4.6.17.3 Orienting Mechanism. The test for backlash in the orienting mechanism is performed in a similar manner as in 4.6.17.2, except that it is necessary to affix a special testing device conforming to Drawing D7647160 to the orienting knob as a zero reference, with the vernier scale resting on the open left cover of the orienting knob. Turn the Aiming Circle telescope in azimuth until its line of sight is directed away from the vertical target line by a few revolutions of the orienting knobs. Then rotate the orienting knobs in the opposite direction until the vertical reticle line of the telescope is superimposed on the vertical target line. Note the reading on the scale of the special testing device. Continue rotating the Aiming Circle in the same direction by a few revolutions of the orienting knobs, and then reverse the direction. Turn back the orienting knobs the same number of revolutions and stop the movement when the same reading is reached on the scale of the special testing equipment. The amount of backlash can be determined by observing the distance between the vertical reticle line of the telescope and the vertical target line. The amount of backlash for the mechanism shall not exceed the tolerance specified in 3.2.3.3.8.

NOTE: If overtravel occurs during the operations described under 4.6.17, the test shall be nullified and the procedures specified for backlash shall again be performed.

4.6.18 Alignment. This test shall be accomplished utilizing special testing equipment conforming to Drawing F7694427. After the equipment and the Aiming Circle are set up in accordance with the set-up and alignment procedures indicated on Sheet 7 of Drawing F7694427, the following procedure shall apply. With the transformer knob "K" of the power supply "M" in zero position, turn switch "L" to the ON position; lamp "J" will be illuminated. Release needle clamp "I" on the Aiming Circle. Rotate transformer knob "K" clockwise until 90 volts is read on the direct current (dc) meter "H". By means of the elevation and orienting knobs on the Aiming Circle, coincide the cross hairs of the telescope with the cross hairs of the collimator reticle while viewing through aperture "G". View through aperture "F" and center the needle index on the magnifier reticle by means of the orienting knobs of the Aiming Circle. With the needle index centered on the magnifier reticle, sight through aperture "G" on the telescope and ascertain if the vertical cross hair of the telescope is within the specified tolerance of 3.2.3.3.3. Return needle clamp "I" to the locked position.

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4.6.19 Lift. With the Aiming Circle mounted on the special testing equipment and leveled, adjust the line of sight so that the horizontal reticle line is superimposed on the horizontal target line. Deflect the azimuth motion of the instrument 1/4 revolution past its starting point while sighting through the telescope, and then reverse the direction of rotation by means of the upper azimuth worm knob. Repeat this procedure a minimum of 4 deflection settings equally spaced for a minimum of one revolution of the instrument in azimuth. This test shall then be performed using the lower azimuth worm knob. Any vertical displacement of the line of sight with respect to the horizontal target line, as a result of reversing azimuth motion by means of either azimuth worm knob, shall be noted and shall not exceed the tolerance specified in 3.2.3.4.

4.6.20 Side Play. Perform this test in sequence to the test in 4.6.19. Adjust the line of sight so that the vertical reticle line is superimposed on the vertical target line. Rotate the elevation knob through its full excursion while sighting through the telescope and then reverse the direction of rotation by means of the elevation knob. Any horizontal movement of the line of sight with respect to the vertical target line shall be noted, and shall not exceed the tolerance specified in 3.2.3.5.

4.6.21 Total Horizontal Error. The total horizontal error in the arithmetic sum of errors of 4.6.13, 4.6.15, and 4.6.20, inspected as described therein, and shall not exceed the tolerance specified in 3.2.3.6.

4.6.22 Compass.

4.6.22.1 Magnetic Needle. Special testing equipment conforming to Drawing F7681312 shall be utilized in performing the test for the requirements of 3.2.3.7.1. Place identical spacers between the tilt table (part 5 of the special testing equipment) and the table stop ring (part 6 of the equipment) so that the table will not tilt. Level the table by means of a precision bench level. Mount the Aiming Circle on the tilt table and adjust the instrument until the level bubbles remain centered. Rotate the table, with spacers removed, or Aiming Circle until the compass needle is oriented in the north-south direction. With the compass needle unlocked and the end of the needle aligned with its line on the compass reticle, as viewed through the magnifier, the 3 degree functional test is made by depressing the tilt table against the stop ring in any position

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required, This test shall be made at standard ambient temperature on the sampling basis specified in Table I, Classification of Defects, and shall be repeated for the extreme temperatures of 3.2.2.2 on the sampling basis specified in 4.4.2.

4.6.22.2 Repeatability. With the Aiming Circle leveled and the compass needle oriented in the north-south direction, unlock the needle and, while sighting through the magnetic needle magnifier, align the end of the needle with the edge of a reticle line. Magnetically deflect the needle to a maximum displacement in both directions and visually check for repeat readings which shall not exceed the tolerance specified in 3.2.3.7.2. This test shall be made for all instruments at standard ambient temperature, and shall then be repeated for the extreme temperatures of 3.2.2.2 on the sampling basis specified in 4.4.2.

4.6.22.3 Half Period. The average half period time is measured by means of a standard stop watch for the requirements of 3.2.3.7.3. If the average half period time is excessive, the compass shall be examined for magnetism of the needle and finish of the pivot point and jewel. In cases where no cause for defects is apparent, a test shall be made for measurement of the earth's magnetic field in terms of minimum oersteds required by 3.2.3.7.3.

4.6.23 Magnifier Assembly Parallax. With the magnetic needle reticle line located at near coincidence with the index of the magnetic needle, the inspector's head is moved from side to side while observing the lines of the reticle and needle through the magnifier assembly. Any apparent movement is considered parallax and shall not exceed the tolerance specified in 3.2.3.8.

4.6.24 Magnetic Needle Magnifier. To aid in the performance of the test, apply a source of illumination into the housing cover window over the needle reticle and damper. The focus of the magnifier at the surface of the needle shall be inspected by means of a dioptometer (see 4.6.9) adjusted to the observer's eye. Direct the line of sight of the dioptometer into the magnifier. Adjust the dioptometer, by movement of the dioptometer tube, for the sharpest view of the magnetic needle etching. The reading on the diopter scale on the tube, indicating error in terms of diopters, shall conform with 3.2.3.9.

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4.6.25 Resolution. The resolving power test shall be accomplished by means of a parallel bar test target as described in the set-up instructions, Drawing F7681321. The resolution target shall be viewed with a 4-power auxiliary telescope, scaled in diopters, held to the Aiming Circle telescope by means of an adapter conforming to Drawing C7659830. The test chart shall be located at the distance indicated in the set-up instructions drawing for the resolution test target, and it shall be clearly illuminated. The test chart's geometric axis shall be in coincidence with the telescope's optical axis. With the telescope focused on the numeral on the resolving power test chart, align the auxiliary telescope's optical axis to the eyepiece of the Aiming Circle telescope. Focus the auxiliary telescope until the numeral on the test chart appears the sharpest. The test pattern shall be resolved in all quadrants for compliance with the tolerance specified in 3.2.3.10.

4.6.26 Open Sight. The open sight shall be checked with the same set-up employed for the test in 4.6.10. With the telescope focused on the target's line of sight mark, the open sight shall read within the limits of the circle on the target described in the set-up instruction, Drawing F7681321, to determine compliance with the requirements specified in 3.2.3.12.

4.6.27 Parallax-Telescope. With the Aiming Circle mounted on the special testing equipment and leveled, parallax shall be checked by sighting through the ocular of the telescope and observing a point of coincidence on a target, adjusted to the distances specified in 3.2.3.13, with respect to a corresponding point of the telescope's reticle in close proximity to the telescope's optical axis. With the target image adjusted to the 50 yard range, parallax between the reticle and target image shall be parallax free as viewed through the eyepiece assembly of the telescope. The target shall contain lines subtending 0.3 mils right and left, up and down from the original coincidence setting. Parallax will be recognized as any apparent displacement of the target's image in relation to the reticle image when the observer's head is moved from side to side or up and down. Any apparent movement of the target image shall not exceed the target tolerance lines at the distance specified in 3.2.3.13.

4.6.28 Magnetic Needle, Clamp, and Release Mechanism. This is a visual, tactile test and is accomplished as described in 3.2.3.14. Testing of the unit shall be conducted at standard ambient temperature on the sampling basis specified in Table I, and shall be repeated at the extreme temperatures of 3.2.2.2 on the sampling basis specified in 4.4.2.

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4.6.29 Torque. The running torque test shall be accomplished by means of a torque wrench type tester, measuring in ounce inches, equipped with an adapter to accommodate testing of the respective knobs. The torque wrench shall be rotated in a clockwise and then in a counterclockwise direction. Readings shall be taken when the knob is in continuous motion throughout its range of movement. The measured values shall not exceed the limits specified in 3.2.3.15 at the temperatures specified.

4.6.30 Illumination. The illumination test for the requirements of 3.2.3.16 is a visual check, and shall be conducted in accordance with MIL-O-13830. Illumination of the reticle shall be accomplished with the lighting instrument energized with a 3 volt source.

5. PACKAGING.

5.1 Packaging, Packing, and Marking. Packaging, packing, and marking shall be in accordance with MIL-P-14232 and Packaging Data Sheet MIL-P-14232/P5800554 for M2 Aiming Circle and Packaging Data Sheet MIL-P-14232/P5911272 for M2A2 Aiming Circle. The level of protection shall be as specified in the procurement document.

6. NOTES

6.1 Intended Use.

Aiming Circle: M2 and M2A2. The Aiming Circle is used to measure limited vertical angles and to measure horizontal angles in azimuth, with respect to magnetic and grid north, for orientation of artillery weapons.

6.2 Ordering Data. Procurement documents should specify the following:

- (a) Title, number, and date of this specification
- (b) Selection of an applicable level of preservation, packaging, and packing.
- (c) Applicable stock numbers.
- (d) Applicable packaging data sheet number (see 5.1).
- (e) Requirements for submittal of first article samples.

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(f) Cautionary Note. Aiming Circle M2 and M2A2 are precision optical instruments having the primary function of accurate measurement of horizontal and vertical angles. The precision of measurement is directly dependent upon the precision of manufacture and fit of a number of critical mechanical components, particularly the worm and worm gear assemblies. The attention of suppliers and potential suppliers is specifically directed to the "Dimensions and tolerances" provisions of MIL-F-13926 and to the need for acquisition or access to special precision test equipment for measurement of tooth-to-tooth error of worm gears.

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DOCUMENT IDENTIFIER (Number) AND TITLE

MIL-A-13338E AIMING CIRCLE: M2 and M2A2

NAME OF ORGANIZATION AND ADDRESS OF SUBMITTER

VENDOR USER MANUFACTURER

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