

MIL-I-22596C(AS)
 17 March 1982
 SUPERSEDING
 MIL-I-22596B(AS)
 23 December 1975

MILITARY SPECIFICATION

INDICATOR, TACHOMETER, ELECTRIC, 0-120 PERCENT RPM, 2-INCH SIZE

This specification is approved for use by the Naval Air Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers design requirements and all performance requirements for procurement of hermetically sealed, remote indicating, percent RPM tachometer indicators.

1.2 Classification. The tachometer indicators covered by this specification shall be classified as follows:

MS21971-1	Unlighted
MS21971-2	Lighted
MS21971-3	Lighted (Glass Coated per MIL-C-14806 for Reflection Reduction)

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. Unless otherwise specified (see 6.2), the following specifications and standards of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DoDISS) specified in the solicitation, form a part of this specification to the extent specified herein.

SPECIFICATIONS

Military

MIL-D-1000/1	Drawings, Engineering and Associated Data
MIL-C-5015	Connectors, Electric, Circular Threaded, AN Type, General Specification for
MIL-S-7742	Screw Threads, Standard, Optimum Selected Series: General Specification for

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Naval Air Engineering Center, Engineering Specifications and Standards Department (Code 93), Lakehurst, NJ 08733, 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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SPECIFICATIONS (Continued)

Military (Continued)

MIL-G-9398	Generator, Tachometer, High Temperature, Two-Pole, Aircraft
MIL-C-14806	Coating, Reflection Reducing, for Instrument Cover Glasses and Lighting Wedges
MIL-L-25467	Lighting, Integral, Red, Aircraft Instrument, General Specification for
MIL-G-26611	Generator, Tachometer, GEU-7/A, Miniature
MIL-I-81400	Instruments, Aircraft, General Specification for

STANDARDS

Military

MIL-STD-109	Quality Assurance Terms and Definitions
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-461	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of
MIL-STD-781	Reliability Tests: Exponential Distribution
MIL-STD-810	Environmental Test Methods
MS21971	Indicator, Tachometer, Electric, 0-120 Percent RPM, 2-Inch Size
MS33558	Numerals and Letters, Aircraft Instrument Dial, Standard Form of
MS33585	Pointers, Dials, Standard Design of Aircraft Instrument

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

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2.1.2 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein, the test of this specification shall take precedence.

3. REQUIREMENTS

3.1 Qualification. Indicators 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. and 6.).

3.2 General design requirements. Selection and use of parts and materials and general requirements for design and construction shall be in accordance with the requirements of MIL-I-81400.

3.3 Selection of Government documents. Specifications and standards for necessary commodities and services not specified herein and in MIL-I-81400 shall be selected in accordance with MIL-STD-143.

3.4 Weight. The weight of the completely assembled indicator shall not exceed 1 pound.

3.5 Performance. The indicators shall perform satisfactorily when subjected to the tests specified in Section 4.

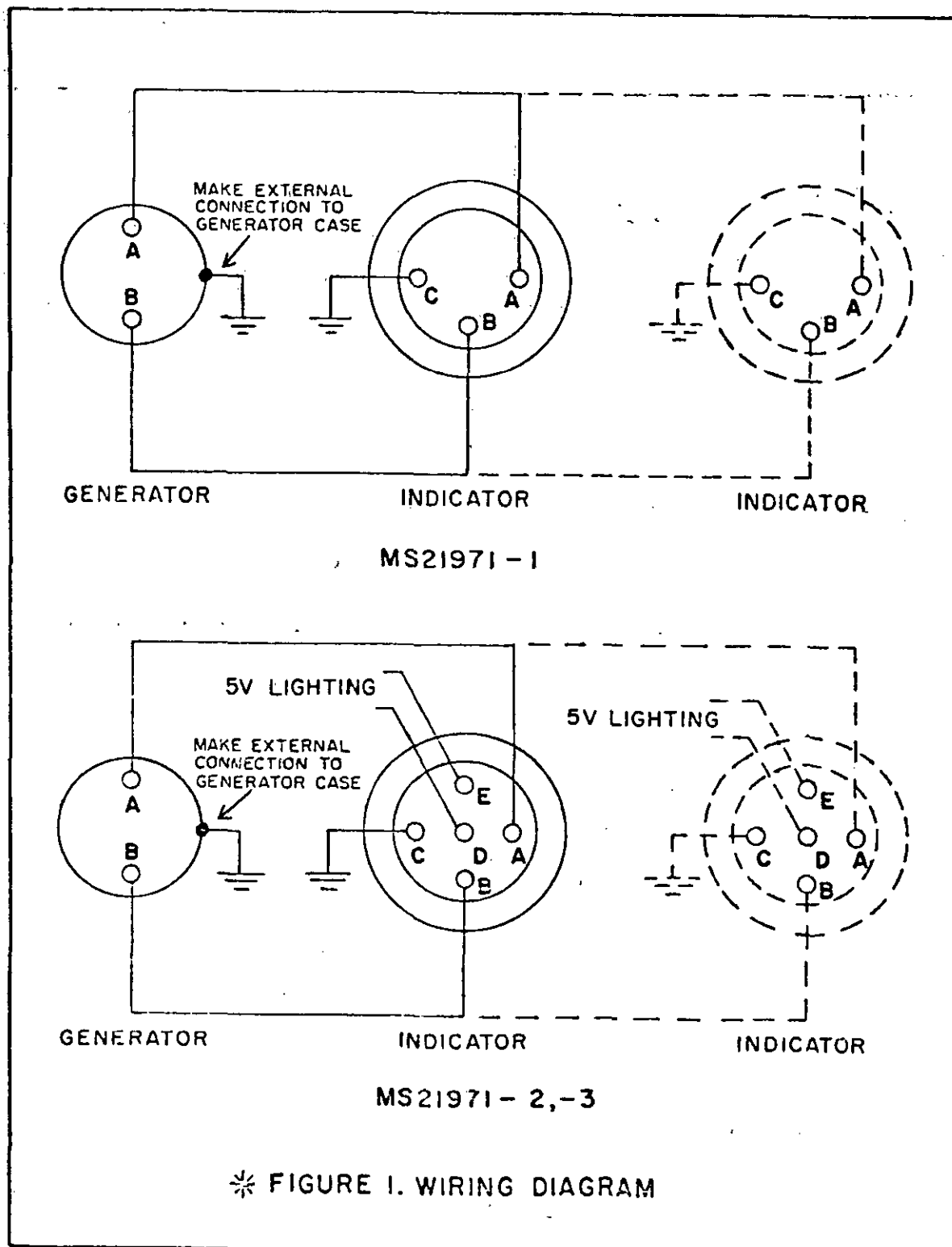
3.5.1 Reliability.

3.5.1.1 Operational stability. The indicator shall operate with satisfactory performance, continuously or intermittently for a period of at least 1500 hours without the necessity for readjustment of any controls which are inaccessible to the operator during normal use.

3.5.2 Reliability in Mean Time Between Failure (MTBF). The indicator shall have 1500 hours of mean (operating) time between failures when tested and accepted as outlined under the requirements of 4.6.32.

3.6 Wiring. The 3 leads from the indicator windings shall be designated as B, A and C (conforming to 1, 2 and 3). The leads shall be connected to the B, A and C pins of the electrical receptacle in such a manner that the indicator reading is positive when 3-phase power with phase sequence B-A-C is applied. Electrical connections for counterclockwise generator shaft rotation (when viewed from the shaft end), for operating one or two indicators, shall conform to the wiring diagram in Figure 1. For clockwise rotation, reverse leads A and B at the generator plug. The wiring shall be isolated from the case.

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3.6.1 Electric connector. The electric connector used shall conform to Requirement 10 of MIL-STD-454, MIL-C-5015 and be of type specified on MS21971.

3.7 Visibility of dial. Visibility of the dial shall be in conformance with MIL-I-81400 except that at least 1/3 of each graduation shall be visible within the cone frustum.

3.8 Dial marking. The dial and subdial shall be marked in accordance with MIL-I-81400 and as shown in Figure 2.

3.9 Pointers. The main dial pointer shall conform to MS33585-8. The subdial pointer shall conform to MS33585-9; its length shall be such that the tip will extend into the scale approximately 1/2 the length of the graduation. The pointers shall otherwise be in accordance with MIL-I-81400.

3.10 Detail requirements. The indicator shall be designed for operation from the varying-frequency alternating-current output of tachometer generators conforming to MIL-G-9398 or MIL-G-26611. The frequency of the generator output shall be the same as the speed at which the generator shaft is rotating. The design shall be such that with increasing and decreasing speeds the pointers shall move smoothly at a rate consistent with the speed change. The design shall be reasonably simple to permit service maintenance, repair or overhaul without requiring special tools and fixtures. The indicator shall be constructed to withstand the normal strains, jars, vibrations and such other conditions as are incident to shipping, storage, installation and service. The indicator shall indicate 0 to 120 percent speed of the engine in approximately 270° of main dial pointer travel and shall indicate 100 percent speed of the engine when the generator is driven at 4200 RPM. The subdial pointer shall make one complete revolution for each 10 percent change in indication of the main dial pointer.

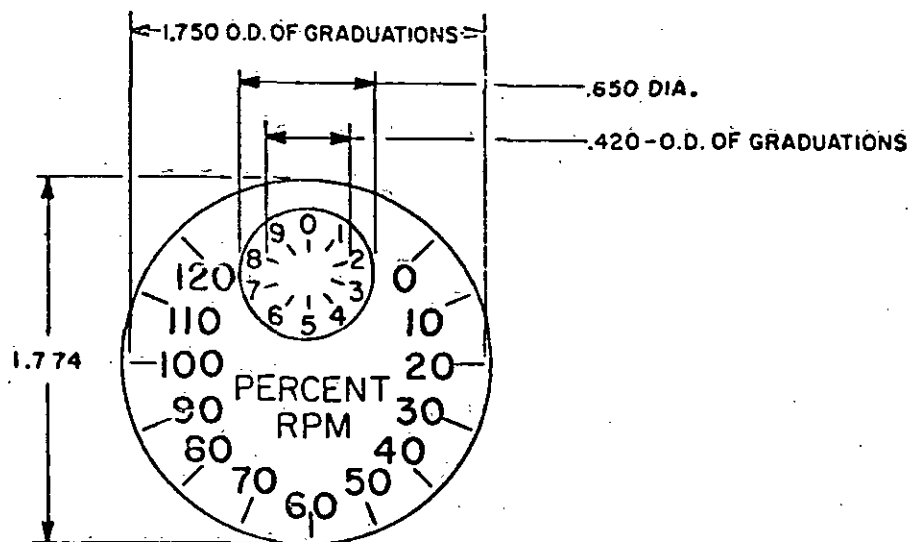
3.10.1 Stop. The indicator shall be provided with a stop which, upon reverse operation of the indicator motor, will stop the pointer motion after traveling through an arc equal or not less than 2 percent nor more than 4 percent RPM.

3.11 Screw threads. Screw threads 0.060 inch or larger in diameter shall be in accordance with MIL-S-7742 and Requirement 12A of MIL-STD-454.

3.12 Manufacturer's part number. Changes in manufacturer's numbers shall be governed by the drawing number requirements of MIL-D-1000/1.

3.13 Case. The indicator case shall be hermetically sealed in accordance with MIL-I-81400 and the outline dimensions of the indicator case shall conform to MS21971.

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MARKING	HEIGHT OR LENGTH $\pm .010$	WIDTH OF LINE OR GRADUATION $\pm .005$	FINISH
MAIN DIAL GRADUATIONS	.140	.025	LUSTERLESS WHITE
NUMERALS	.140	.023	
PERCENT	.062	.011	
RPM	.125	.016	
SUB-DIAL CIRCUM. LINE THICKNESS		.008	LUSTERLESS BLACK
GRADUATIONS	.050	.012	
NUMERALS	.093	.016	
DIAL BACKGROUND	--	--	

DIMENSIONS IN INCHES.

LETTERS AND NUMERALS IN ACCORDANCE WITH MS33558.

Figure 2. Dial Markings

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3.14 Identification of product.

3.14.1 Nameplate. A nameplate shall be securely attached to the exterior of the case and shall be marked in accordance with the requirements of MIL-STD-130 except that the FSN shall be omitted.

3.15 Reflection reduction coating. The MS21971-3 indicator shall be provided with a reflection reduction coated cover glass and lighting wedges where applicable in accordance with MIL-C-14806.

3.16 Electromagnetic interference. The indicator shall comply to the requirements of MIL-STD-461, Parts one and two for Class Alb equipment using the procedures of MIL-STD-462.

4. QUALITY ASSURANCE PROVISIONS

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

4.2 Classification of inspections. Items covered by this specification shall be subjected to the following inspections to determine compliance with all applicable requirements.

- (1) Qualification inspection
- (2) Quality conformance inspection

4.3 Qualification inspection. The qualification inspection shall consist of all the tests of 4.6 performed in the order listed and shall include the reliability test for the Reliability Qualification (Demonstration) Phase, and samples submitted for qualification (see 4.3.1) shall be accompanied by the contractor's report showing that this reliability phase (4.6.32.1) has been satisfactorily met by the other samples.

4.3.1 Qualification inspection samples. Qualification inspection samples shall consist of a minimum of 6 samples. The samples submitted shall have been previously subjected only to the individual inspections. Three samples shall be forwarded at the contractor's expense to the laboratory designated in the letter of authorization (see 6.4). At least three samples shall be retained by the contractor for the Reliability Qualification (Demonstration) Phase, which will be run by the contractor at his plant.

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4.3.1.1 Qualification inspection sample identification. The qualification inspection samples shall be plainly identified by durable tags, securely attached, and marked with the following information:

Sample for Qualification Inspection
Indicator, Tachometer, Electric; 0-120 Percent RPM,
2-Inch Size
Submitted by (Manufacturer's name, date and part number)
for Qualification Inspection in accordance with
Specification MIL-I-22596C(AS) under authorization
(reference letter authorizing tests).

4.4 Quality conformance inspection. The contractor shall furnish all samples and shall be responsible for accomplishing all the inspections except sampling plan B inspections, which will be conducted at a Government laboratory designated by the procuring activity. Quality conformance inspection, except for sampling plan B, shall be under the supervision of the Government quality control representative. The contractor shall furnish test reports showing detailed quantitative results for all tests required by this specification, signed by an authorized representative of the contractor or laboratory as applicable. Acceptance or approval of material during the course of manufacture shall in no case be construed as a guarantee of the acceptance of the finished product. Quality conformance inspection shall consist of the following tests:

- a. Individual
- b. Sampling plan A
- c. Sampling plan B
- d. Reliability assurance

4.4.1 Individual inspection. Each indicator submitted for acceptance shall be subjected to the individual inspection. These tests shall determine compliance with the requirements of material, workmanship, operational adequacy and reliability. As a minimum, each instrument accepted shall have passed the following tests:

Examination of product
Lighting (Individual tests and MIL-L-25467)
(Lighted type indicators only)
Starting - Room temperature
Scale Error - Room temperature
Friction error
Position error
Pointer alignment
Dielectric strength
Power consumption

4.4.2 Sampling plans. The sampling plans shall consist of sampling plan A and sampling plan B. The inspection samples selected for sampling tests shall first have passed the Individual inspection. The test samples which have been subjected to sampling plan A test shall

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not be delivered on contract until they have been refurbished and resubmitted and passed all the Individual tests. Test samples which have been subjected to the sampling plan B shall not be delivered on contract.

<u>Quantity Offered for Acceptance</u>	<u>Quantity to be Selected for Sampling Plan A Tests</u>
First 15	1 (Zero when sampling plan B is invoked)
Next 50	1
Next 75	1
Next 100	1
Each additional 200 or fraction thereof	1

When a defective indicator is detected, no items from those still on hand or later produced shall be accepted until the extent and cause of failure have been determined and appropriately corrected. In addition, when a failure occurs, shift to one sample out of the next fifteen and proceed as indicated (one from next 50, etc.).

4.4.2.1 Sampling plan A inspection. Each sample selected for sampling plan A shall be subjected to the following tests:

Leakage
Precipitation : fog
Magnetic effect
Lighting (MIL-L-25467, sampling plan A,
lighted type indicators only)
Starting - low temperature
Scale error - low temperature
Scale error - high temperature
Vibration error

4.4.2.2 Sampling plan B inspection. One indicator shall be selected at random from the first 15 produced on contract and submitted within 10 days after manufacture. These samples shall be forwarded at the contractor's expense to a Government laboratory designated by the procuring activity. Each sample shall be plainly identified by a durable tag, securely attached and marked with the following information:

Indicator, Tachometer, Electric, 0-120 Percent
RPM, 2-Inch Size
Submitted by (Manufacturer's name, date)
for production acceptance sampling plan B
test of MIL-I-22596C(AS) in accordance with
Contract/Order No. _____
Manufacturer's Part No. _____

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4.4.2.2.1 Sampling plan B approval. Approval of sampling plan B indicators shall be of the procuring activity upon satisfactory completion of the designated tests. Any design, material or performance defect made evident during this test shall be corrected by the contractor to the satisfaction of the procuring activity. Failure of the sample units to pass any of the tests shall be cause for deliveries of indicators under the contract to cease until proper corrective action is approved and accomplished.

4.4.2.2.2 Sampling plan B inspection. Each sample selected for sampling plan B inspection shall be subjected to the following tests:

Sampling plan A
 Vibration failure
 High temperature exposure
 Low temperature exposure
 Overspeed and reverse operation
 Life
 Lamp life (MIL-L-25467 lighted type indicators only)
 Thermal shock
 Test for helium
 Contrast, lamp circuit, dielectric (sampling plan B, MIL-L-25467, lighted type indicators only)
 Internal examination

4.5 Standard conditions for test. Unless otherwise specified, all inspections required by this specification shall be made under the following conditions:

Temperature	Room ambient $25^{\circ} + 5^{\circ}\text{C}$
Pressure	Normal atmospheric (approximately 29.92 inches Hg)
Humidity	Room ambient up to 90 percent relative humidity
Input lighting power	$5 + 0.5\text{V DC}$, or, AC, $400 + 5\text{ Hz}$ (lighted indicators only)

4.5.1 Test readings. Unless otherwise specified, before a test reading is taken, the indicator shall either be lightly tapped or shall be vibrated using a vibrator set at a frequency between 30 and 120 C.P.S. with an amplitude between 0.001 and 0.002 inch double amplitude.

4.5.2 Attitude. Unless otherwise specified, the indicator shall be tested in its normal operating position with the dial face vertical.

4.5.3 Electrical power. Unless otherwise specified, tests requiring the operation of the indicator shall be conducted utilizing the output of tachometer generators conforming to MIL-G-9398, MIL-G-26611, or an equivalent power source.

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4.5.4 Lighting system. The indicator lighting system of MS21971-2 and MS21971-3 indicators shall be energized during all tests except the thermal shock and salt spray tests, and shall operate satisfactorily after completion of each test.

4.5.5 Operation. Unless otherwise specified, 2 single indicators shall be connected to, and be operated from, one tachometer generator.

4.5.6 Tolerances. Where tolerances are given in percent, this percentage is in percent RPM (as on the dial face), and not percent full scale.

4.6 Test methods. The procedure specified herein shall be supplemented by a procedure outlined in detail by the contractor. This procedure shall state the exact conditions under which measurements are to be made. The procedure shall include details for test of all electrical, mechanical and performance characteristics as specified for the particular instrument, including provisions for indicating all variations in characteristics measured during the test procedure. This procedure is subject to the approval of the procuring activity.

4.6.1 Performance check under standard conditions. (Reference Run) - Prior to conducting environmental tests, the equipment shall be instrumented and checked for satisfactory performance under standard conditions. This performance check shall be made in accordance with the approved test procedure. A record shall be made of all data necessary to determine the complete operational and performance characteristics. This check shall include operation throughout the indicator range, and all phases of appropriate service operation and check situations (see paragraph 3.2.1 of MIL-STD-810).

4.6.2 Examination of product. Each indicator shall be examined to determine conformance with workmanship, applicable drawings, and other requirements not covered by tests.

4.6.3 Lighting (Individual Tests (MIL-L-25467)). The MS21971-2 and MS21971-3 indicator shall be subjected to and shall meet the requirements of the Individual Tests of MIL-L-25467.

4.6.4 Starting - room temperature. The indicator shall be connected to a variable frequency power supply. The supply voltage shall be 0.0035 times the frequency in cycles per minute. The frequency of the supply shall be slowly increased from zero cycles per minute and the speed at which the indicator begins to operate at synchronous speed shall be noted. This speed shall not exceed 180 RPM.

4.6.5 Scale error - room temperature. The indicator shall be connected as shown in Figure 1 to a generator, and tested at points of the scale indicated in either Table I or Table II. The test shall be

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TABLE I. Tolerance.

GENERATOR DRIVE SHAFT SPEED	CORRECT INDICATED SPEED	TOLERANCE			
		Room Temperature	-54°C	-5°C	+71°C
RPM	Percent RPM	± Percent RPM	± Percent RPM		
0 †	0	0.5	0.6	0.6	0.5
210 †	5	0.5	0.6	0.6	0.5
420 †	10	0.5	0.6	0.6	0.5
630	15	0.5	-	-	-
840 †	20	0.5	0.7	0.6	0.5
1260	30	0.6	-	-	-
1680 †	40	0.8	1.2	1.1	1.0
2100	50	0.8	-	-	-
2520 †	60	0.8	1.4	1.1	1.0
2940	70	0.8	-	-	-
3150 †	75	0.5	1.3	0.8	0.8
3360 †	80	0.5	1.4	0.8	0.8
3570 †	85	0.5	1.4	0.9	0.8
3780 †	90	0.5	1.5	0.9	0.8
3990 †	95	0.5	1.5	0.9	0.8
4200 †	100	0.5	1.5	0.9	0.8
4410 †	105	0.5	1.6	1.0	0.8
4620	110	0.5	-	-	-
4830	115	0.5	-	-	-
5040 †	120	0.5	1.6	1.0	0.8

† Test points for scale error at -54°C, -5°C and +71°C.

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TABLE II. Tolerance.

SPEED	CORRECT INDICATION	TOLERANCE			
		Room Temperature	-54°C	-5°C	+71°C
RPM	Percent RPM	+ Percent RPM	+ Percent RPM		
0	0	0.5	0.6	0.6	0.5
200 †	4.76	0.5	0.6	0.6	0.5
400 †	9.52	0.5	0.6	0.6	0.5
600	14.29	0.5	-	-	-
800 †	19.05	0.5	0.7	0.6	0.5
1200	28.57	0.6	-	-	-
1600 †	38.10	0.8	1.2	1.1	1.0
2000	47.62	0.8	-	-	-
2400 †	57.14	0.8	1.4	1.1	1.0
2800	66.67	0.8	-	-	-
3200 †	76.19	0.5	1.3	0.8	0.8
3400 †	80.95	0.5	1.4	0.8	0.8
3600 †	85.71	0.5	1.4	0.9	0.8
3800 †	90.48	0.5	1.5	0.9	0.8
4000 †	95.24	0.5	1.5	0.9	0.8
4200 †	100.00	0.5	1.5	0.9	0.8
4400 †	104.76	0.5	1.5	0.9	0.8
4600	109.52	0.5	-	-	-
4800	114.29	0.5	-	-	-
5000 †	119.05	0.5	1.5	0.9	0.8

† Test points for scale error at -54°C, -5°C and +71°C.

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made either by driving the generator at speeds necessary to produce the specified indicator readings and reading the speed of the generator or by driving the generator at the specified speeds and reading the indicator. The test shall be made with speeds increasing and with speeds decreasing. With speeds increasing, the speed shall be brought up to, but shall not exceed the desired speed or indication for each test point. With speeds decreasing, the speed shall be brought down to, but shall not fall below this desired value. The errors at the test points shall not exceed the tolerances specified in the applicable table. When the speed is held constant at any test point, the pointer shall not oscillate over a range greater than 0.5 percent from 0 to 15 percent and 0.3 percent from 15 to 120 percent.

4.6.6 Friction error. The indicator shall be set at the 5, 20, 40, 70, 85, 100 and 115 percent graduations. After each setting, the indicator shall be tapped and the change in indication noted. This change shall not exceed 1.5 percent at the 5 percent graduation, 0.7 percent at the 20 percent graduation and 0.5 percent at the 40, 70, 85, 100 and 115 percent graduations.

4.6.7 Position error. Vibration, as specified in paragraph 4.5.1, shall be applied to the instrument throughout this test. The indicator shall be operated with an input provided to produce an indication of 100 percent RPM in the normal (dial vertical) position. The instrument shall then be moved slowly from the normal position to the specified test positions and the indications shall be continuously observed. The maximum difference in indications from the normal position indication shall be recorded. The indications observed at each of the test positions shall also be recorded. The maximum recorded deviation from the normal position shall not exceed 0.3 percent RPM. The indicator should be positioned as follows:

- a. Rotated from normal position through 90 degrees until the dial is face up.
- b. Rotated from normal position through 90 degrees until the dial is face down.
- c. Rotated from normal position through 360 degrees with the dial remaining vertical. Readings shall be taken at 90 degree increments of position and at the point of the maximum difference in indication.

4.6.8 Pointer alignment. The indicator shall be operated so that the main pointer is centered on the 90 percent graduation. The subdial pointer shall then indicate 0 within 0.4 percent.

4.6.9 Dielectric strength. A potential of 200 volts (root mean square) alternating current at commercial frequency shall be applied between isolated pins and between pins and case for a period of 5 seconds. There shall be no breakdown of insulation or any other permanent damage to the indicator as a result of this test. The calculated resistance shall be not less than 5 megohms.

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4.6.10 Power consumption. The indicator shall be connected to a 21-volt, 4,200 cycle per minute power supply. The current drawn by any one of the 3-phase lines shall not exceed 0.30 ampere.

4.6.11 Leakage. The indicator shall be tested for case leakage with a mass spectrometer helium leak detector or by an equivalent, at least equally sensitive, quantitative leakage test. The rate of leakage, adjusted to a pressure differential of one atmosphere, shall not exceed one micron cubic foot per hour.

4.6.12 Precipitation or fog. The indicator shall be placed in a test chamber. The temperature of the circulating air shall be $85^{\circ} \pm 5^{\circ} \text{C}$ and the indicator shall be kept in the chamber for 2 hours. The indicator shall then be removed from the chamber and within 30 seconds the indicator face shall be immersed to a depth of 1 to 2 inches in a water bath maintained at $4^{\circ} \pm 3^{\circ} \text{C}$. After 5 minutes, the indicator shall be removed from the bath and dried. There shall be no evidence of moisture or other deposits on the inner face of the cover glass.

4.6.13 Magnetic effect. The indicator (first operating at approximately 90 percent RPM and then not operating) the nearest point of which is 5-1/2 inches from the magnetic East or West of a short-bar magnetic compass from which the compensating magnets have been removed, shall be rotated through 360 degrees about each of 2 mutually perpendicular axes. The compass deflection, in any case shall not exceed 1 degree. The horizontal field intensity shall be between 0.17 and 0.19 oersted.

4.6.14 Lighting (sampling plan A tests MIL-L-25467). The MS21971-2 and MS21971-3 indicator shall be subjected to and shall meet the requirements of the sampling plan A tests of MIL-L-25467.

4.6.15 Starting - low temperature. This inspection shall be performed in accordance with Procedure I, Low Temperature tests of MIL-STD-810. The temperature of the circulating air shall be -54°C , for at least 4 hours before the test is started. No voltage shall be applied to the indicator terminals during this period. After 4 hours the indicator shall be connected to a variable frequency power supply. The frequency of the supply shall be slowly increased from zero CPM and the speed at which the indicator begins to operate at synchronous speed shall be noted. This speed shall not exceed 180 RPM.

4.6.16 Scale error - low temperature.

4.6.16.1 Scale error at -54°C . Following the starting test at low temperature (4.6.15) and while still at -54°C , the indicator readings at the points indicated by daggers in Table I or II shall be determined. The frequency of the supply shall be brought up to but shall not exceed the frequency specified in Table I or II. The change in reading of the indicator from the original room temperature reading (4.6.5) at any test point shall not exceed the value specified in Table I or II.

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4.6.16.2 Scale error at -5°C . The temperature shall then be set at -5°C and the indicator maintained at this temperature for at least 4 hours after the circulating air has stabilized. No voltage shall be applied to the indicator terminals during this period. After 4 hours the indicator shall be connected to the variable frequency power supply used in 4.6.15. The indicator readings at the points indicated by daggers in Table I or II shall be determined. The frequency of the supply shall be brought up to but shall not exceed the frequency specified in Table I or II. The change in reading of the indicator from the original room temperature reading (4.6.5) at any test point shall not exceed the value specified in Table I or II. After at least 4 hours following return to room temperature, the indicator shall be subjected to and shall meet the requirements of 4.6.5 and 4.6.6.

4.6.17 Scale error - high temperature. This inspection shall be performed in accordance with Procedure I, High Temperature tests of MIL-STD-810 except that the indicator shall be kept in the chamber for 4 hours after the temperature of $+71^{\circ}\text{C}$ is reached before the test is started. The change in reading of the indicator from the original room temperature reading (4.6.5) at any test point shall not exceed the value specified in Table I or II. After at least 4 hours following return to room temperature, the indicator shall be subjected to and shall meet the requirements of 4.6.5 and 4.6.6.

4.6.18 Vibration error. The indicator reading shall be determined at any indication between 60 and 90 percent RPM that is selected by the inspector, then the indicator shall be subjected to vibrations as specified in Procedure I of MIL-STD-810. The indicator reading shall be determined first without vibration, and then as the vibration frequency is varied from 300 to 3,000 CPM. The readings with vibration shall not vary more than 0.7 percent from the readings without vibration. The amplitude of the pointer oscillation shall not exceed 0.7 percent.

4.6.19 Vibration failure. This test shall be conducted in accordance with Procedure I or MIL-STD-810. The indicator shall be operating at approximately 90 percent RPM throughout the vibration period. Scale error tests (4.6.5) shall be conducted immediately prior to, and upon completion of the vibration test. The respective readings shall not differ by more than 0.5 percent at any test point. In addition, no looseness in the mechanism nor damage to any part of the indicator shall result from this test.

4.6.20 High temperature exposure. This test shall be performed in accordance with Procedure II of High Temperature tests of MIL-STD-810 except that the time at $+71^{\circ}\text{C}$ shall be 24 hours. While still at $+71^{\circ}\text{C}$, a scale error test shall be conducted and the errors shall not exceed those allowed in Table I or II. Not less than 4 hours after the indicator has returned to room temperature, the indicator shall be subjected to and meet the requirements of 4.6.5 for increasing speeds only and 4.6.6. There shall be no damage which would adversely affect subsequent operation.

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4.6.21 Low temperature exposure. This test shall be performed in accordance with Procedure I, Low Temperature tests of MIL-STD-810 except that the indicator shall first be subjected to the temperature of -62°C for a period of 48 hours. The temperature shall then be raised to -54°C . After 24 hours, and while still at this temperature, the indicator shall first be subjected to and meet the requirements of the starting - low temperature test (4.6.15) and the scale error at -54°C test (4.6.16.1). After the chamber has returned to room temperature and the indicator has remained at room temperature for 4 hours, the indicator shall be subjected to and meet the requirements of 4.6.5 and 4.6.6.

4.6.22 Overspeed and reverse operation. The indicator shall be electrically connected to a tachometer generator and the errors of the indicator shall be determined when operated at 20 and 90 percent RPM. The indicator shall be at room temperature and the readings shall be taken before the indicator temperature has risen appreciably. The generator and the indicator shall then be operated, first at a generator shaft speed of approximately 5,600 RPM for a period of 5 minutes, then in the reverse direction of rotation at a generator shaft speed of approximately 2,500 RPM for a period of 1 minute. After the indicator has been allowed to cool to room temperature, the errors of the indicator shall again be determined when operated at 20 and 90 percent RPM. The change in errors at the respective test points before and after the overspeed and reverse operation test shall not be more than 0.5 percent.

4.6.23 Electromagnetic interference. The indicator shall be subjected to, and meet, electromagnetic interference requirements in accordance with MIL-STD-461 and MIL-STD-462.

4.6.24 Life. The readings of the indicator shall be determined when the input is the equivalent of 20 and then 90 percent RPM. The indicator shall be at room temperature and the readings shall be taken before the indicator temperature has risen appreciably. The indicator shall then be operated at an indication of 90 ± 5 percent RPM for a period of 1,000 hours. The voltage at the indicator terminals shall be 18.5 ± 1 volt during the 1000-hour period. At the end of the 1000-hour period and after the indicator has cooled to room temperature, the readings of the indicator shall again be determined when the input is 20 and 90 percent RPM. The difference in respective readings obtained before and after this test shall not be more than 0.5 percent. No screws of other parts shall become loose or damaged as a result of this test. Indicators which have been subjected to all the tests of this specification up to and including this test shall again be subjected to the scale error test at room temperature, friction error, and position error tests. Scale error shall not be 0.5 percent more than allowed at room temperature in Tables I and II. Friction error shall not exceed 1.5 percent at the 5 and 20 percent indications and 1.0 percent at the 40, 70, 85, 100 and 115 percent graduations. Position error shall not exceed 0.5 percent.

4.6.25 Lamp life. The MS21971-2 and MS21971-3 indicator shall be subjected to the life test specified in MIL-L-25467. (This test may be run concurrently with the life test specified in 4.6.24.)

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4.6.26 Thermal shock. The indicator shall be subjected to 4 cycles of exposure to water at $85^{\circ} \pm 2^{\circ}\text{C}$ and $5^{\circ}\text{C} \pm 2^{\circ}\text{C}$ without evidence of moisture penetration or damage to finish or enclosures. Each cycle of the test shall consist of immersing the indicator in water at 85°C for a period of 30 minutes and then, within 5 seconds of removal from the bath, the indicator shall be immersed for a period of 30 minutes in the other bath maintained at 5°C . This cycle shall be repeated continuously, one-cycle following the other, until 4 cycles have been completed. Following this test the indicator shall be subjected to, and meet the leakage test.

4.6.27 Salt fog. The indicator shall be subjected to a 50 hour Salt Fog test in accordance with Procedure I of MIL-STD-810. External connections shall be made to the indicator in such a manner as to simulate installed conditions. The indicator shall then be subjected to and meet the requirements of dielectric strength (4.6.9) and leakage (4.6.11) tests within one hour of removal from salt fog and again at the end of 50 hours. The indicator shall have been washed with distilled water immediately upon removal from the salt fog.

4.6.28 Shock. The indicator, operating at approximately 90 percent RPM, shall be subjected to Shock Test, Procedure I or MIL-STD-810. Following this test the scale error (4.6.5) and friction (4.6.6) tests shall be conducted. The indicator shall meet the requirements of these tests within the tolerances listed in the life test (4.6.24).

4.6.29 Test for helium. The indicator case shall be punctured or the filling tube cut, and the indicator subjected to the test for helium with a mass spectrometer helium detector. Failure to detect helium shall be cause for rejection.

4.6.30 Contrast, lamp circuit, dielectric. The MS21971-2 and MS21971-3 indicator shall be subjected to, and meet all the contrast, lamp circuit and dielectric requirements of tests specified in MIL-L-25467.

4.6.31 Internal examination. The indicator shall be examined internally for evidence of damage resulting from the tests specified herein. There shall be no evidence of corrosion or deterioration.

4.6.32 Reliability assurance tests. Reliability assurance tests shall be conducted using MIL-STD-781. Qualification (Demonstration) Phase and Production Acceptance (Sampling) Phase Tests shall be conducted. Equipments selected for reliability assurance tests shall first have passed the Individual tests.

4.6.32.1 Reliability Qualification Phase. Prior to Qualification Product Listing (QPL), a minimum of three (3) test samples shall be tested as outlined in MIL-STD-781, under the section titled "Qualification (Demonstration) Phase of Production Reliability Tests." The maximum number of test samples to be used shall be those listed in Table 5 of MIL-STD-781. Test Level F shall be used for the Qualification Phase. The Accept-Reject Criteria for Test Plan I shall be used.

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4.6.32.2 Reliability Production Acceptance (Sampling) Phase tests. Samples of the equipment shall be tested as outlined in MIL-STD-781, under the section titled "Production Acceptance (Sampling) Phase of Production Reliability Tests." Test Level F shall be used for the Reliability Production Acceptance (Sampling) Phase. The Accept-Reject criteria for Test Plan II shall be used to determine the length of the tests (until an accept or reject decision is reached).

4.6.32.2.1 Procedure for Production Acceptance (Sampling) Phase. The Reliability Production Acceptance (Sampling) Phase tests shall be conducted on each lot (see 6.3) during the life of the contract. The number of samples shall not be less than 3 nor more than 7. The test program shall start after the Qualification (Demonstration) Phase has been completed. The samples shall be tested until an accept or reject decision is reached. In the mean time other equipments constructed shall be shipped. The test results shall be summarized for the procuring activity. The procuring activity reserves the right to stop the acceptance of equipment at any time after one or more reject decisions have been reached, pending a review of the contractor's efforts to improve the equipment, the equipment quality control, etc., so that the entire contract quantity will show an accept decision.

4.6.32.3 Procedures report and test details. The test details such as the length of the test cycle, the length of the heat portion of the cycle, the performance characteristics to be measured, special failure criteria, preventive maintenance to be allowed during the test, etc., shall be part of the test procedures report to be submitted to and approved by the procuring activity prior to the beginning of the Qualification (Demonstration) test phase of the Reliability Assurance tests. The following paragraphs shall be considered as minimum requirements and apply to both phases.

4.6.32.3.1 Duty cycle. The duty cycle shall be continuous. The duty cycle shall consist of operating the indicator as described in the life test (4.6.24) except for the length of the test.

4.6.32.3.2 Performance characteristics to be measured. The scale and friction error at 20 and 90 percent RPM shall be determined as in the life test except on a daily basis. The scale and friction error at those points shall not exceed 1.0 and 1.5 percent RPM, respectively, multiplied by

$$\left(1 + \frac{\text{Total Time on Reliability Test (each instrument)}}{\text{Specified MTBF}}\right)$$

4.6.32.3.3 Failure criteria. Whenever performance characteristics fall below the acceptance requirements (4.6.32.3.2), at least one failure has occurred. If subsequent analysis reveals that several parts have deteriorated, each should be counted a failure unless the procuring activity and the contractor agree that one part caused the other parts to fail.

4.6.32.3.4 Preventive maintenance. No preventive maintenance may be accomplished on the samples while they are on test.

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4.6.32.4 Disposition of samples upon completion of tests. Any sample tested may be delivered on contract provided it meets all the following requirements:

- a. It is representative of production units currently being accepted.
- b. It is in "good as new" condition or has been refurbished (see 6.3).
- c. It is otherwise satisfactory.

5. PREPARATION FOR DELIVERY

5.1 Preparation for delivery shall be in accordance with MIL-I-81400.

6. NOTES

6.1 Intended use. The indicator covered by this specification is intended for use in aircraft to indicate the rotational speed of a jet or prop-jet engine in percent RPM. The calibration is based on a generator speed of 4,200 RPM at 100 percent rated engine speed.

6.2 Ordering data. Procurement documents should specify:

- a. Title, number and date of this specification.
- b. Quantity and MS number (including dash number) of indicator desired) (see 1.2).
- c. Levels of packaging and packing (see 5.1).
- d. Laboratory that will conduct tests (see 4.4).
- e. Reliability test reports (see 4.3 and 4.6.32.3).
- f. Lot (see 6.3.3).

6.3 Definitions. The following definitions supplement those in MIL-I-81400 and MIL-STD-109.

6.3.1 Hermetic seal. A hermetic seal shall be a perfectly closed and air tight seal made between metallic and metallic or between metallic and vitric materials. A hermetic seal is not intended to include seals which are dependent upon gaskets.

6.3.2 Good as new. "Good as new" shall mean instruments operated less than 10 percent of the specified MTBF Operation.

6.3.3 Lot. A lot is defined as three months production or as defined in the contract.

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6.4 Qualification. With respect to products requiring qualification, awards will be made only for such products as have, prior to the time set for the opening of bids, been tested and approved 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 might 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 Naval Air Systems Command, Department of the Navy, Washington, DC 20360, and information pertaining to qualification of products may be obtained from that activity.

6.5 Precedence of documents. When the requirements of the contract, this specification, or applicable subsidiary specifications are in conflict, the following precedence applies.

a. Contract. The contract shall have precedence over any specification.

b. This specification. This specification shall have precedence over all applicable subsidiary specifications. Any deviation from this specification, or from subsidiary specifications where applicable, shall be specifically approved in writing by the procuring activity.

c. Referenced specifications. Any referenced specification shall have precedence over all applicable subsidiary specifications referenced therein. All referenced specifications shall apply to the extent specified.

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