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MILITARY SPECIFICATION

INDICATOR, TEMPERATURE, THERMOCOUPLE, SELF-BALANCING, POTENTIOMETER TYPE

This specification has been approved by the Department of the Air Force and by the Bureau of Naval Weapons.

1. SCOPE

1.1 Scope.- This specification covers self-balancing potentiometer type temperature indicators.

1.2 Classification.- Indicators shall be furnished in the following part numbers, as specified (see 6.2):

MS24569-1	Linear scales with a main dial and a subdial pointer.
MS24569-2	Single pointer with nonlinear scale.
MS24569-3	Single pointer with linear scale and digital counter.

2. APPLICABLE DOCUMENTS

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

SPECIFICATIONS

Federal

PPP-B-636	Box, Fiberboard

Military

MIL-P-116	Preservation, Methods of
MIL-E-5272	Environmental Testing, Aeronautical and Associated Equipment, General Specification for
MIL-E-5400	Electronic Equipment, Aircraft, General Specification for
MIL-W-5846	Wire, Electrical, Chromel and/or Alumel, Thermocouple
MIL-I-6181	Interference Control Requirements, Aircraft Equipment
MIL-P-7936	Parts and Equipment, Aeronautical, Preparation for Delivery
MIL-L-25467	Lighting, Integral, Aircraft Instrument, General Specification for

FSC 6685

MIL-M-26512	Maintainability Program Requirements, for Aerospace Systems and Equipment
MIL-R-26667	Reliability and Longevity Requirements, Electronic Equipment, General Specification for
MIL-D-70327	Drawings, Engineering and Associated Lists

STANDARDS

Federal

Federal Standard No. 595	Colors

Military

MIL-STD-129	Marking for Shipment and Storage
MIL-STD-130	Identification Marking of US Military Property
MIL-STD-143	Specifications and Standards, Order of Precedence for the Selection of
MIL-STD-704	Electric Power, Aircraft, Characteristics and Utilization of
MIL-STD-785	Military Data Requirements for Reliability Program (for Systems and Equipments)
MIL-STD-831	Test Reports, Preparation of
MS3106	Connector, Plug, Electric, Straight
MS24569	Indicator, Temperature Thermocouple, Self Balancing Potentiometer Type
MS33558	Numerals and Letters, Aircraft Instrument Dial, Standard Form of
MS33585	Pointer, Dial, Standard Design of Aircraft Instrument
MS33586	Metals, Definition of Dissimilar
MS33639	Cases, Instrument, Clamp-Mounted, Aircraft
MS33678	Connector, Receptacle, Electric, Integral Mounting

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

2.2 Other publications.- The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply:

National Bureau of Standards

Circular 561	Reference Tables for Thermocouples

(Application for copies should be addressed to the Superintendent of Documents, Government Printing Office, Washington, D. C. 20402.)

Uniform Classification Committee

Uniform Freight Classification Rules

(Application for copies should be addressed to the Uniform Classification Committee, 202 Chicago Union Station, Chicago, Illinois 60606.)

3. REQUIREMENTS

3.1 Qualification.- The indicators furnished under this specification shall be products which have been subjected to and which have passed the qualification tests specified herein, and which have been listed on or approved for listing on the applicable Qualified Products List.

3.2 Materials.-

3.2.1 Nonmagnetic materials.- Nonmagnetic materials shall be used for all parts of the indicator, except where magnetic materials are essential.

3.2.2 Nonferrous materials.- Nonferrous materials shall be used for all parts of the indicator, except where ferrous materials are essential.

3.2.3 Metals.- Metals shall be of the corrosion-resistant type or shall be suitably treated to resist corrosion due to fuels, salt spray, or atmospheric conditions likely to be met in storage or normal service.

3.2.4 Dissimilar metals.- Unless suitably protected against electrolytic corrosion, dissimilar metals shall not be used in intimate contact with each other. Dissimilar metals are defined in MS33586.

3.2.5 Toxic and corrosive fumes.- The indicator shall be of such material and construction that toxic and corrosive fumes, when burned, or gases that combine with the atmosphere to form acid or corrosive alkali will not be liberated.

3.2.6 Protective treatment.- When materials are used in the construction of the indicator that are subject to deterioration when exposed to climatic and environmental conditions likely to occur during service usage, they shall be protected against such deterioration in a manner that will in no way prevent compliance with the performance requirements of this specification. The use of any protective coating that will crack, chip, or scale with age or extremes of climatic and environmental conditions shall be avoided.

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

3.4 Preliminary list of electronic parts.- A preliminary list of electronic parts shall be furnished directly to the procuring activity in accordance with MIL-E-5400 prior to ordering or fabricating parts for the production quantity. The parts shall also conform to MIL-E-5400. Nonstandard parts shall be approved by the procuring activity prior to fabrication of the completed item. Standard electronic parts shall be used whenever practicable. Nonstandard electronic parts shall not constitute more than 50 percent of the total quantity of electronic parts used in the construction of the indicator.

3.5 Design and construction.- The design and construction of the indicator shall include all of the circuitry necessary for converting chromel-alumel thermocouple signals to temperature indication on the aircraft instrument panel, a self-balancing potentiometer-type circuit for temperature measurements, and a dial conforming to either MS24569-1, -2, or -3, as specified in the contract or order.

3.5.1 Power consumption.- The indicator power consumption shall not exceed 10 volt amperes (va) exclusive of the lighting circuit.

3.5.2 Power supply.- The indicator shall be designed to operate from a 115V 400-cycle, single-phase power supply conforming to MIL-STD-704, except that the voltage and frequency each may vary ±10 percent. Operation with surge voltages shall be as specified in 4.6.13.

3.5.3 Temperature signals.- The indicator shall be designed to operate on signals generated by chromel-alumel thermocouples. The values of the signals shall be as specified in the National Bureau of Standards Circular 561.

3.5.4 Reliability program.- The contractor shall establish a reliability assurance program in accordance with MIL-STD-785.

3.5.4.1 The indicator shall have a minimum mean-time-between-failures (MTBF) of 500 hours at a 90 percent confidence level.

3.5.5 Maintainability.- The contractor's maintainability program shall be in accordance with MIL-M-26512, exclusive of appendix A, except as specified in 4.6.27.

3.5.5.1 The following maintainability requirements shall be considered in the design of the indicator:

(a) Optimum accessibility of components requiring maintenance.

(b) Rapid and positive identification of replaceable defective parts, assemblies, or components.

(c) Minimum number and types of tools and test equipment (special and standard) required to perform maintenance.

3.6 Performance.- The indicator shall be capable of meeting the following requirements:

(a) Scale error: Scale error not exceeding the tolerances specified in table I.

(b) Friction error: Friction error not exceeding ±2° C between 100° and 1,200° C for the MS24569-1 and MS24569-3 indicators and ±3° C between 510° and 790° C for the MS24569-2 indicator.

(c) Position error: Position error not exceeding 1° C.

(d) Sealing: Case leakage not exceeding 0.1 micron cubic foot per hour with a nitrogen-helium mixture and 1.0 micron cubic foot per hour with a 100 percent helium mixture.

(e) Warmup: Warmup and pointer travel from 100° to 1,000° C within 6 seconds at room temperature and 10 seconds -55° and +100° C.

(f) Response: Instantaneous indication change from 500° to 850° C in not more than 2 seconds at room temperature and 100° C and 3 seconds at -55° C.

TABLE I. Indicator tolerances

Test points ° C	Room temp. scale error ±° C	Low temp. scale error ±° C	High temp. scale error ±° C	Scale error during reliability ±° C	Position error ±° C	Friction error ±° C
MS24569-1 and MS24569-3						
100	10.0	15.0	15.0	15.0	—	2.0
200	5.0	10.0	10.0	10.0	—	2.0
400	5.0	10.0	10.0	10.0	—	2.0
500	5.0	10.0	10.0	10.0	—	2.0
600	5.0	10.0	10.0	10.0	1.0	2.0
700	5.0	10.0	10.0	10.0	1.0	2.0
800	5.0	10.0	10.0	10.0	1.0	2.0
900	5.0	10.0	10.0	10.0	—	2.0
1,000	5.0	10.0	10.0	10.0	—	2.0
1,100	5.0	10.0	10.0	10.0	—	2.0
1,200	10.0	15.0	15.0	20.0	—	2.0
MS24569-2						
100	15.0	20.0	20.0	20.0	—	—
200	15.0	20.0	20.0	20.0	—	—
400	15.0	20.0	20.0	20.0	—	—
510	5.0	10.0	10.0	10.0	—	3.0
600	5.0	10.0	10.0	10.0	2.0	3.0
700	5.0	10.0	10.0	10.0	2.0	3.0
790	5.0	10.0	10.0	10.0	2.0	3.0
900	15.0	20.0	20.0	20.0	—	—
1,000	15.0	20.0	20.0	20.0	—	—
1,100	15.0	20.0	20.0	20.0	—	—
1,200	15.0	20.0	20.0	20.0	—	—

(g) Sensitivity: Indication change at points between 600° C and 800° C not exceeding 2° ± 1° C when a millivoltage signal change of 0.08 millivolt (mv) is made.

(h) Temperature: Operation at temperatures ranging from -65° C to +100° C.

(i) Vibration: Withstand applied vibration in accordance with Procedure XII, Curve B of MIL-E-5272.

(j) Clutch and stop effect: Withstand an alternate input of -3 and +52 mv for a period of 30 minutes at each value for 8 cycles at a 50° C ambient temperature.

(k) Thermocouple circuit resistance effect: Indication change not to exceed 2° C when a lead resistance change from 5 to 200 ohms is made at specified test points between 200° and 1,000° C.

(l) Grounding and open circuiting the thermocouple extension wires: Indicator steady state change not to exceed 2° C when either the chromel or alumel conductor is grounded separately at any point to the ground side (low potential side) of the 115V 400-cycle power supply for a 1-minute period. Indicator response to an open thermocouple circuit shall be a downscale indication as described in 4.6.17.

(m) Stray signal and beat frequency tolerance: Withstand the effects of the beat frequencies in the power input and stray ac signals in the thermocouple circuit as specified in 4.6.

(n) Altitude: Withstand pressures ranging from 30 inches mercury (Hg) down to 0.309 inch Hg (approximately 100,000-foot altitude).

(o) Magnetic effect: When positioned 5-1/2 inches from a bar magnet which produces a field strength of 0.17 to 0.19 oersted at the indicator, the compass deflection shall not exceed 5 degrees angular.

(p) Voltage and frequency variation: Withstand frequency variations ranging from 360 to 440 cycles per second (cps) and voltage variations from 104 to 126V.

(q) Thermal shock and fogging test: Withstand 8 cycles of immersion in tapwater maintained at 85° ±2° C and +5° ±2° C.

(r) Power-off warning: Withstand 20,000 deflections of the power-off mechanism at 15 ±2 deflections per minute.

(s) Salt spray: Exposure to a salt sea atmosphere for a period of 50 hours.

(t) Voltage surge: Withstand voltage surges to 195 ±5V root mean square (rms).

3.6.1 Interference control.- The indicator shall be designed to suppress internally radiated and conducted radio noise within the limits specified in MIL-I-6181 and shall meet the susceptibility requirements specified therein.

3.7 Interchangeability.- All parts having the same manufacturer's part number shall be functionally and dimensionally interchangeable. The item identification and part number requirements of MIL-D-70327 shall govern the manufacturer's part numbers and changes thereto.

3.8 Case.- The indicator case shall be hermetically sealed and shall conform to MS33639 for the nominal 2-inch diameter. The finish of the case shall be durable dull black. The seal shall be accomplished in a manner that will not be dependent upon materials that will be affected by the action of any atmosphere to which the case will be subjected. The front edge of the case shall not extend beyond the outer surface of the cover glass by more than 1/32 inch. The design of the case shall be such that the internal mechanism may be removed from the case, replaced, and the case resealed without the use of special tools unless they are approved by the procuring activity. The case length shall be 5-7/8 ±1/8 inches for the -1 and -2 indicators and shall be 6-3/8 ±1/8 inches for the -3 indicator. A ground lug on the inner surface of the case back plate shall be used to ground the case through pin F of the electrical receptacle.

3.8.1 Filling medium.- The filling medium shall be of at least 98 percent purity, free of dust particles, and shall contain not more than 0.006 milligram of water vapor per liter (dewpoint -65° C) at the filling pressure. The filling medium shall be either 100 percent helium or a mixture of 88 percent to 92 percent nitrogen and the remainder helium. The absolute pressure of the filling medium in the case shall be approximately 1 atmosphere. Where practicable, the filling medium shall be 100 percent helium. The manufacturer shall state in his test report the filling medium(s) used in the indicator (see 4.3.2).

3.8.2 Filler tube.- A tube or other facilities used for evacuating and filling the case shall be provided at the rear of the case and shall be recessed beneath the level of the back plate surface.

3.8.3 Nameplate.- A nameplate shall be provided on the rear of the case. The information shall conform to MIL-STD-130 where applicable. Metal cals shall not be used.

3.9 Dials.- The indicator dials shall be integrally lighted in accordance with MIL-L-25467. Dials shall have a minimum diameter of 1-3/4 inches as measured across the outer ends of the main dial graduations and shall conform to MS24569 and the requirements specified herein for the respective indicators.

3.9.1 MS24569-1 dial.- This dial shall be linear and shall consist of a main dial and a subdial. The subdial shall have a diameter of 5/8 ±1/64 inch with scale graduations fabricated on the main dial plate. All graduations shall be linear within 0.5 of an angular degree. The scale arc of the main dial shall be 270 ±1 degrees. The subdial may be fabricated on a counterbored surface in the main dial plate or on a recessed disk beneath the level of the main dial plate, provided the viewing angle is at least as good as that of the main dial.

3.9.2 MS24569-2 dial.- This dial shall consist of only a main dial which is nonlinear, but the adjacent scale graduations located within the contracted and expanded sections of the dial shall be within 0.5 of an angular degree of precise linear spacing. The scale arc of the dial shall be 340 ±1 degrees.

3.9.3 MS24569-3 dial.- This dial shall be linear within 0.5 angular degree between adjacent graduations and shall contain an opening in the scale plate for viewing a digital counter which indicates temperature in degrees Centigrade. The dial shall conform to MS24569-3. The scale arc of the dial shall be 240 ±1 degrees. The units wheel of the counter shall indicate temperature in increments of 2° C and shall be numbered as follows: 0, 2, 4, 6, 8, 0, 2, 4, 6, 8. All other wheels shall be numbered from 0 to 9.

3.9.3.1 Counter.- The digital counter shall conform to MS24569-3 and to other requirements specified herein. The counter shall be constructed exclusively of metals and shall be of the internal pinion construction. The space between numerals on a particular counter wheel shall be approximately 0.020 inch. The counter shall be designed for a minimum shaft speed of 200 revolutions per minute (rpm) continuous and 1,000 rpm intermittent and shall have a minimum life of 10 million revolutions of the drive shaft at 200 rpm without additional lubrication or counter malfunction. The drive shaft and gears shall be made of metal. The shaft shall rotate on stainless steel ball bearings. Brass gears or pinions shall not be used.

3.9.4 Pointers.-

3.9.4.1 Main dial pointers.- The main dial pointer shall conform to MS33585-8, except the width of the pointer tip shall be 0.020 ±0.005 inch. A minimum length of 0.60 inch of the main dial pointer shall be visible for all positions of the pointer. The pointer shall be integrally lighted in accordance with MIL-L-25467. Deviations to MS33585-8 will be permitted as required to accomplish the specified integral lighting.

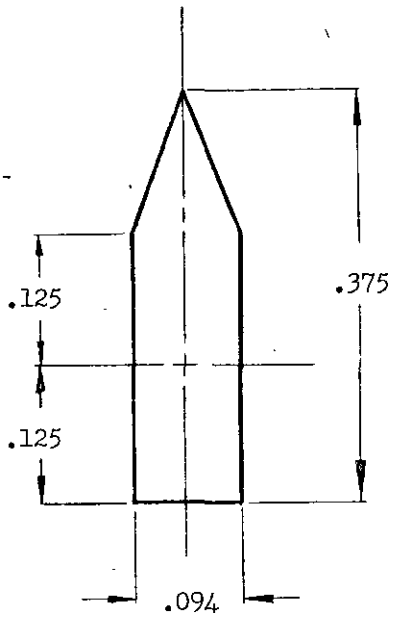
3.9.4.2 Subdial pointer.- The subdial pointer shall conform to figure 1. The entire length of the subdial pointer shall be lighted in accordance with MIL-L-25467. In lieu of a subdial pointer, an illuminated pointer configuration on a black rotating disk may be used, provided the lighting conforms to all requirements of MIL-L-25467. The length of the pointer is the distance from pointer tip to center of the pointer hub or pivot point.

3.9.4.5 Dial-to-cover glass distance.- The maximum distance between the inner surface of the cover glass and the indicator dial shall be 0.188 inch.

3.10 Power "OFF" warning.- The indicator shall be provided with a power "OFF" warning as shown on MS24569. The warning shall display the word "OFF" in black letters, color No. 17038 of Federal Standard No. 595, and for Air Force procurement, on a conspicuous red background which shall conform to Lawter Chemical Incorporated daylight fluorescent red No. 34, or equal. For Navy procurement, the background of the warning flag shall be lusterless white, color No. 37875 of Federal Standard No. 595. The warning shall remain in view until 115V 400-cycle power is appled for operation. When power is applied to the indicator, the warning shall move from view within 1 second and shall be replaced by a dull black surface. The warning shall be operated from the power supply of the indicator. The background of the warning shall be transilluminated when the warning is in view with power applied.

3.11 Numerals and letters.- Unless otherwise specified, numerals and letters shall conform to MS33558.

3.12 Thermocouple cold junction compensation.- The indicator shall incorporate temperature compensation for the thermocouple cold junction within the indicator. Temperature control at the cold junction shall not be used. The compensation shall be such that the input temperature signal to the indicator circuit is independent of the temperature changes at the cold junction within the accuracy requirements of this specification.



DIMENSIONS IN INCHES. TOLERANCES: ±.016

FIGURE 1. Subdial pointer for MS24569-1 indicator

3.13 Reference voltage.- The reference voltage, if required for the self-balancing potentiometer, shall be derived from the power supply in the indicator. Standard cells shall not be used.

3.14 Markings.-

3.14.1 Dimensions and colors.- The dimensions and colors of the dials, pointers, and counter markings shall be as specified in table II. The colors shall be in accordance with Federal Standard No. 595.

3.15 Electrical receptacle.- The indicator shall be provided with an MS33678-18-9P electrical receptacle, except that the receptacle shall be hermetically sealed. Pins A and D of the receptacle shall be made of alumel and chromel materials, respectively.

3.15.1 Wiring.- The receptacle shall be wired as follows:

Pin	External connection
A	Alumel conductor
B	Open
C	115V 400-cps input
D	Chromel conductor
E	5V ac or dc input for lighting
F	115V 400-cps and 5V ground. Case ground
G	Open

3.16 Weight.- The weight of the -1 and -2 indicators shall not exceed 1.5 pounds. The weight of the -3 indicator shall not exceed 1.75 pounds.

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

3.18 Workmanship.- The indicator shall be constructed and finished in a thoroughly workmanlike manner. Particular attention shall be given to neatness and thoroughness of soldering, wiring, impregnation of coils, welding, brazing, plating, painting, riveting, machine screw assemblies, and freedom of parts from burrs and sharp edges. Mating gears shall provide a minimum of backlash necessary for smooth operation. Where necessary, antibacklash techniques shall be used.

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.

TABLE II. Dial, pointer, and counter markings

	Height or length (inch ±0.005)	Width of line or graduation (inch ±0.005)	Color No.
MS24569-1			
Main dial numerals	0.156	0.031	37875
Main dial major graduations	.156	.031	37875
Main dial minor graduations	.094	.031	37875
Subdial numerals	.094	.020	37875
Subdial graduations	.062	.020	37875
Lettering: "TEMP." "°C x 100"	.094	.020	37875
"OFF"	.094	.020	17038
Pointers	---	---	37875
Background of dial	---	---	37038
Background of "OFF" warning	(See MS24569)	---	(See 3.10)
MS24569-2			
Numerals	0.156	0.031	37875
100° C graduations	.156	.031	37875
50° C graduations between 500 and 800	.156	.031	37875
50° C graduations except between 500 and 800	.125	.031	37875
10° C graduations	.125	.020	37875
Lettering: "TEMP." "°C x 100"	.094	.020	37875
"OFF"	.094	.020	17038
Pointer	---	---	37875
Background of dial	---	---	37038
Background of "OFF" warning	(See MS24569)	---	(See 3.10)
MS24569-3			
Dial numerals	0.156	0.031	37875
Major graduations	.156	.031	37875
Minor graduations	.094	.031	37875
Lettering: "TEMP." "°C x 100°	.094	.020	37875
"OFF"	.094	.020	17038
Pointer	---	---	37875
Background of dial	---	---	37038
Background of "OFF" warning	(See MS24569)		(See 3.10)
Counter numerals	.188	.031	37875
Background of counter numerals	---	---	37038

4.2 Classification of inspections.- The examination and testing of the indicator shall be classified as follows:

(a) Qualification inspections (4.3)
(b) Quality conformance inspections (4.4)

4.3 Qualification inspections.-

4.3.1 Sampling instructions.- The qualification samples shall consist of eight indicators representative of the production equipment. The samples shall be identified with the manufacturer's own part number and such other information as required by the

procuring activity. Five of the indicators shall be used for reliability testing (see 4.6.26.1) and the other three indicators shall be subjected to all tests specified under 4.6, except reliability. In addition, three "OFF" warnings and three counters not previously endurance cycled or otherwise damaged shall be submitted complete and suitable for cycling tests for qualification approval.

4.3.2 Qualification report and samples.- When tests are performed at a location other than the laboratory of the activity responsible for qualification (see 6.3), the following shall be furnished to that activity:

(a) Reports: Three copies prepared in accordance with MIL-STD-831.
(b) Samples: The samples that were tested in the "as is" condition (see 4.3.1).

4.3.3 Inspections.- The qualification inspections shall consist of all the inspections described under 4.6.

4.4 Quality conformance inspections.- Quality conformance inspections shall consist of examinations and tests as specified in 4.4.1, 4.4.2, and 4.6.

4.4.1 Individual tests.- Each indicator shall be subjected to the following tests as specified under 4.6 and in MIL-L-25467:

(a)	Examination of product	(4.6.1)
(b)	Individual tests of MIL-L-25467	(See MIL-L-25467)
(c)	Scale error and friction at room temperature	(4.6.2)
(d)	Position error	(4.6.3)
(e)	Sealing	(4.6.4)
(f)	Burn-in	(4.6.5)

4.4.2 Sampling plans and tests.-

4.4.2.1 Sampling plan A.- One indicator shall be selected at random from each 100 or less produced on the contract or order and subjected to the following tests as specified under 4.6 and in MIL-L-25467.

(a)	Individual tests	(4.4.1)
(b)	Sampling plan A tests of MIL-L-25467	(See MIL-L-25467)
(c)	Warmup period	(4.6.6)
(d)	Response time	(4.6.7)
(e)	Sensitivity	(4.6.8)
(f)	Low temperature and compensator lag	(4.6.9)
(g)	High temperature and compensator lag	(4.6.10)
(h)	Clutch and stop effect	(4.6.12)
(i)	Voltage surge	(4.6.13)

4.4.2.2 Sampling plan B.- Unless otherwise specified, 3 indicators shall be selected at random from the first 15 on the contract or order and subjected to the following tests as specified under 4.6 and in MIL-L-25467.

(a)	Sampling plan A tests	(4.4.2.1)
(b)	Sampling plan B tests of MIL-L-25467	(See MIL-L-25467)
(c)	Vibration	(4.6.11)
(d)	Low-temperature exposure	(4.6.14)

(e)	High-temperature exposure	(4.6.15)
(f)	Thermocouple lead resistance effect	(4.6.16)
(g)	Grounding and open circuiting of the thermocouple circuit	(4.6.17)
(h)	Stray signal and beat frequency toleration	(4.6.18)
(i)	High-altitude-low temperature	(4.6.19)
(j)	Interference control	(4.6.20)
(k)	Magnetic effect	(4.6.21)
(l)	Voltage and frequency variation	(4.6.22)
(m)	Thermal shock and fogging	(4.6.23)
(n)	Reliability	(4.6.26.1 and 4.6.26.2)
(o)	Cycling of power "OFF" warning	(4.6.24)
(p)	Salt spray	(4.6.25)

4.4.2.3 Rejection.- When one item selected from a production run fails to meet the specification, no items still on hand or later produced shall be accepted until the extent and cause of failure have been determined and appropriately corrected.

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

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

4.5 Test conditions.-

4.5.1 Standard atmospheric conditions.- Whenever the pressure and temperature existing at the time of the test are not specified definitely, it is understood that the test is to be made at atmospheric pressure (approximately 29.92 inches Hg) and at room temperature (approximately 25° C). When tests are made with atmospheric pressure or room temperature differing materially from the above values, proper allowance shall be made for the difference from the specified condition.

4.5.2 Attitude.- Unless otherwise specified, the indicator shall be tested in the normal operating position with the plane of the dial vertical.

4.5.3 Power supply.- Unless otherwise specified, the indicator shall be tested with 115 ±2V, single-phase and 400 ±5 cps ac, with 4.5 ±0.5V ac or dc applied to the lighting circuit.

4.5.4 During testing of the indicator, the power "OFF" warning shall be observed for proper operation.

4.5.5 Integral lighting.- The integral lighting tests shall be conducted in the sequence specified and in accordance with the methods specified in MIL-L-25467. The background of the power "OFF" warning shall be lighted to a brightness level of 2 ±1 foot-lambert. The counter numerals shall be lighted to a brightness level of 1.5 ±0.5 foot-lamberts. Brightness measurements on the "OFF" warning on the counter numerals shall be taken, using the voltage specified in MIL-L-25467 for brightness measurements on the dial.

4.6 Inspection methods.-

4.6.1 Examination of product.- The indicator shall be inspected to determine compliance with this specification with respect to materials, workmanship, and markings.

4.6.2 Scale error and friction at room temperature.- The millivoltage values specified in NBS Circular 561 for chromel-alumel thermocouples 0° C reference for the test points specified in table I shall be applied to the indicator. The indicator shall be lightly tapped or vibrated before each reading to remove normal instrument friction. The scale errors shall not exceed the tolerances specified in table I. Upon completion of or concurrent with the scale error test, the friction error shall be determined by slowly changing the millivolt input between test values until the next test value of millivolts is reached. When a test value is reached, the pointer indication shall be recorded before and after the instrument is lightly tapped or vibrated. The difference between the first and second recordings at each test point shall be recorded as the friction error. The difference between the second reading and the specified test point shall be recorded as the scale error when these test are conducted concurrently. On this and subsequent tests, the power "OFF" warning shall be observed for proper operation. The friction error test shall be conducted while going from 100° to 1,200° C and return to 100° C. The friction error shall not exceed 2° C for the MS24569-1 and MS24569-3 indicators and shall not exceed 3° C for the MS24569-2 indicator at the test points shown in table I.

4.6.3 Position error.- Millivolts shall be applied to the indicator to produce indications of 600°, 700°, and 800° C. With each indication, the indicator shall be rotated clockwise and counterclockwise through an angle of 180 degrees in each direction. The plane of the dial shall then be turned to a horizontal plane face up and face down. The millivolts shall be held constant with ±0.02 mv at each test point. The indication shall not change by more than 1° C, as viewed on the counter or on the subdial, in any of the above positions at the test points specified for the MS24569-1 and MS24569-3 indicators and shall not exceed 2° C for the MS24569-2 indicator at the 600°, 700°, and 790° C scale graduations.

4.6.4 Sealing.- The indicator case shall be tested for leaks by means of a mass-spectrometer-type helium leak detector. Where a nitrogen-helium mixture is utilized as the filling medium, the detected leak rate shall not exceed 0.1 micron cubic foot per hour at a pressure differential of 1 atmosphere. Where 100 percent helium is utilized as the filling medium, the leak rate shall not exceed 1.0 micron cubic foot per hour.

4.6.5 Burn-in.- The indicator shall be placed in a chamber and the temperature shall be maintained at 50° C for a minimum of 24 hours. Power shall be applied in accordance with 4.5.3 throughout the test while maintaining a constant signal input, which shall be determined at the beginning of the test, to provide an indication of 700° C. At least 8 hours of this test shall be performed during normal working hours; observations shall be made and recorded at least once each hour throughout the 8-hour period. The indication change shall at no time exceed 5° C. Pointer oscillation, erratic movement of the pointer, or flag malfunction shall be cause for rejection. The indicator shall then be returned to room temperature for a minimum period of 2 hours after which it shall meet the test specified in 4.6.2.

4.6.6 Warmup period.- Millivoltage and 115V 400-cycle power shall be applied to the indicator to provide an indication of 100° C. The power supply shall then be turned off and the millivoltage adjusted to provide an indication of 1,000° C. The power shall then be reapplied and the time required for the pointer to reach a stable indication, within 5° C of the preset 1,000° C indication, shall be noted. The time required to reach the stable indication shall not exceed 6.0 seconds. One hour shall elapse between the initial power application and the final power application to insure that the indicator is essentially at room temperature.

4.6.7 Response time.- Millivoltage and power shall be applied to provide a stable indication of 500° C. The millivoltage shall then be increased to produce an instantaneous change equivalent to 350° C. The time required for the indicator to fully respond to the 350° C change shall be noted and shall not exceed 2 seconds. This procedure shall be repeated beginning at 850° C and instantaneously reducing the millivoltage equivalent to a change of 350° C. The same tolerance shall apply.

4.6.8 Sensitivity.- Millivoltage and power shall be supplied to provide test point indications of 600°, 700°, and 800° C for the MS24569-1 and MS24569-3 indicators. A change in the millivoltage equivalent to 2° C shall be made at each test point and a change of 2° ±1° C in indication shall result. The test points for the MS24569-2 indicator shall be 600°, 700°, and 790° C. The same tolerances shall apply.

4.6.9 Low temperature and compensator lag.- The indicator shall be placed in a chamber at room temperature. Millivoltage and power shall be applied to produce a steady indication of 700° C. While maintaining the millivoltage constant within 0.02 mv and the power input within 115 ±2V 400 ±5 cps, temperature shall be reduced to -55° ±2° C at a rate of approximately 5° C per minute and held at this temperature for 4 hours. While the temperature is being reduced, the indication shall not change by more than 5° C. When the -55° C temperature is reached, the indication shall be reduced to 100° C and the power removed until the end of the 4-hour period. The millivolt input shall then be adjusted to a value corresponding to 1,000° C, power applied, and the warmup, response time, sensitivity, and scale error tests 4.6.6, 4.6.7, 4.6.8, and 4.6.2, respectively, performed. The warmup time shall not exceed 10 seconds; the response time shall not exceed 3 seconds; the sensitivity shall be as specified in 4.6.8; and scale error tolerances shall not exceed those specified in table I for low temperature.

4.6.10 High temperature and compensator lag.- The indicator shall be tested as specified in 4.6.9, except that the temperature of the chamber shall be raised to 100° C. The warmup time shall not exceed 10 seconds and the response time shall not exceed 2 seconds. The sensitivity shall be as specified in 4.6.8. The scale error shall not exceed that specified in table I for high temperature.

4.6.11 Vibration.- The indicator shall be subjected to a vibration test in accordance with Procedure XII, curve B of MIL-E-5272. Pointer or counter oscillation shall not exceed 5° C double amplitude. The test point shall be 700° C with power and signal applied. Partial deflection of the power "OFF" warning shall be cause for rejection.

4.6.11.1 Following the vibration test, the indicator shall be checked for scale error and friction as specified in 4.6.2. The scale error and friction tolerances shall not exceed those specified in table I for room temperature. No screws or other parts shall become loosened or damaged as a result of vibration.

4.6.12 Clutch and stop effect.- The indicator shall be operated to indicate a temperature of 200° C. The input millivolts shall be instantaneously increased to 52 mv, maintained for 30 minutes, and reduced to provide an indication of 1,000° C. The millivoltage shall then be instantaneously reduced to -3 mv, held for 30 minutes, and returned to the original value used to produce the 200° C indication. The above procedure shall constitute 1 cycle and shall be repeated until 8 cycles have been completed. The scale error test specified in 4.6.2 shall be repeated and the scale error tolerances shall not exceed those specified in table I for scale error at room temperature. A 0° C reference junction temperature shall be maintained throughout the test. This test shall be conducted with the indicator in an ambient temperature of 50° C.

4.6.13 Voltage surge.- The indicator shall be connected as specified for the voltage and frequency test and the indication set at 700° C. The voltage and frequency shall be adjusted to 115 ±1V 400 ±2 cps. A voltage surge shall be applied to the power input to provide a momentary rms voltage of 160 ±5V and return to 115 ±1V. The duration of the surge, including rise and decay time, shall be 0.09 ±0.005 second. The frequency shall then be increased to 440 ±2 cps and a voltage surge applied to provide a momentary rms voltage of 195 ±5V and return to 115 ±1V. The duration of the surge, including rise and decay time, shall be 0.02 ±0.005 second. The voltage and frequency shall then be adjusted to 115 ±1V 400 ±2 cps and accuracy tests conducted at the 600°, 700°, and 800° C test points. The scale error tolerances shall not exceed those specified in table I for scale error at room temperature.

4.6.14 Low-temperature exposure.- The indicator shall be placed in a chamber and subjected to a temperature of -65° ±2° C for 48 hours. While still at this temperature,the indicator shall be operated throughout the scale range and shall exhibit no sticking or erratic characteristics. The temperature shall then be raised to -54 ±2° C and maintained for 24 hours. At the end of this time and while at this temperature, power shall be applied to the indicator. The warmup time shall not exceed 10 seconds and the response time shall not exceed 3 seconds. The indicator shall then be subjected to the scale error test specified in 4.6.2. The scale error tolerances shall be as specified in table I for low temperature. The indicator shall then be returned to room temperature for a minimum period of 2 hours and then subjected to a scale error test as specified in 4.6.2. The scale error tolerances shall not exceed those specified in table I for room temperature scale error.

4.6.15 High-temperature exposure.- The indicator shall be placed in a chamber and subjected to a temperature of 100° ±2° C for a period of 24 hours. Power shall be applied continuosly through the last 2 hours of this period. While still at this temperature, the indicator shall be operated throughout its range and shall exhibit no sticking or erratic characteristics. The indicator shall then be subjected to and meet the requirements of the high temperature scale error test (4.6.10). The indicator shall then be returned to room temperature for a minimum period of 2 hours and subjected to a scale error at room temperature test as specified herein. The scale errors shall not exceed the tolerances specified in table I for scale error at room temperature. The indicator shall then be subjected to the response time test specified herein. The response time shall not exceed 2 seconds.

4.6.16 Thermocouple lead resistance effect.- The indicator shall be subjected to a lead resistance change from 5 ohms to 200 ohms at 510° C, 600° C, 700° C, and 790° C test points for the MS24569-2 indicator, and at 200° C, 500° C, 800° C, and 1,000° C test points for the MS24569-1 and MS24569-3 indicators. The indicator change shall not exceed 2° C.

4.6.17 Grounding and open circuiting of the thermocouple circuit.- The chromel or plus (+) wire and the alumel or minus (-) wire shall be alternately connected to the grounded or low potential side of the 115V 400-cycle power supply. Prior to the grounding of a wire, the scale error shall be determined at the 600° and 700° C test points and the response time shall be determined in the 500° to 850° C scale range on increasing temperature. The scale error and response tests shall be performed with each lead alternately grounded. The scale error with either lead grounded shall not differ from the scale error without a lead grounded by more than 2° C. The response times with the leads alternately grounded shall not differ from the response times without a lead grounded by more than 1 second. The grounding may be accomplished at any point along the conductor between the indicator receptacle and the signal source. Successive indications of 1,000° C, 700° C, and 400° C shall be obtained with power and the required input signals applied. With each indication each of the thermocouple lead shall be alternately opened for a minimum period of 20 seconds. With each open circuit, the indication shall be reduced at an average rate of not less than 30° C per second.

4.6.18 Stray signal and beat frequency toleration.- The indicator shall be connected as shown on figure 2 and all switches opened. With the power supply to the lamp loads turned off, 115V 400-cycle power and a thermocouple signal producing an indication of 700° C shall be applied to the indicator. After 2 minutes at the 700° C indication, the cathode ray oscilloscope and the power supply to the lamp loads shall be turned on and allowed to warm up for 2 minutes. Beginning with a frequency of 380 cps, the frequency of the variable frequency supply shall be increased at a rate not exceeding 1 cps each 5 seconds until 420 cps is reached. The temperature indication shall be closely observed throughout this test. Changes in pointer or counter position and pointer or counter oscillation shall be recorded and the frequency noted. This procedure shall be repeated with only the S-1 switch closed; S-1 and S-2 switches closed; S-1, S-2, and S-3 switches closed; S-1, S-2, S-3, and S-4 switches closed; and then with all switches closed. During this test, each of the thermocouple leads shall be alternately grounded with each group of switches closed. Pointer or counter oscillation shall be cause for rejection. The maximum change in pointer or counter position throughout the test shall not exceed 4° C. If sluggishness is observed during any of the specified conditions, the response-time test (4.6.7) shall be conducted with the worst condition maintained. The response time shall not exceed 3 seconds. With only the S-1, S-2, and S-3 switches closed, a section of the cable containing all of the conductors except the 5V lighting input conductor shall be laid against the entire length of the indicator and then across the indicator at various positions on the case length. Pointer or counter oscillation and pointer or counter variation shall be observed at each position of the cable as the frequency is varied from 380 to 420 cps as specified herein. Pointer or counter oscillation shall not exceed 5° C double amplitude and pointer or counter variation shall not exceed 4° C. The response-time test (4.6.7) shall then be conducted with the worst condition maintained. The response time shall not exceed 3 seconds. The 115V 400 ±2 cps power supply shall be turned off and the cable shall be extended to the rear of the indicator. The integral lighting circuit shall then be supplied with 4.5 ±0.5V at the building supply frequency while the 115V frequency supply to the indicator is varied from 380 to 420 cps. Pointer or counter oscillation shall be cause for rejection. Pointer or counter variations shall not exceed 1° C.

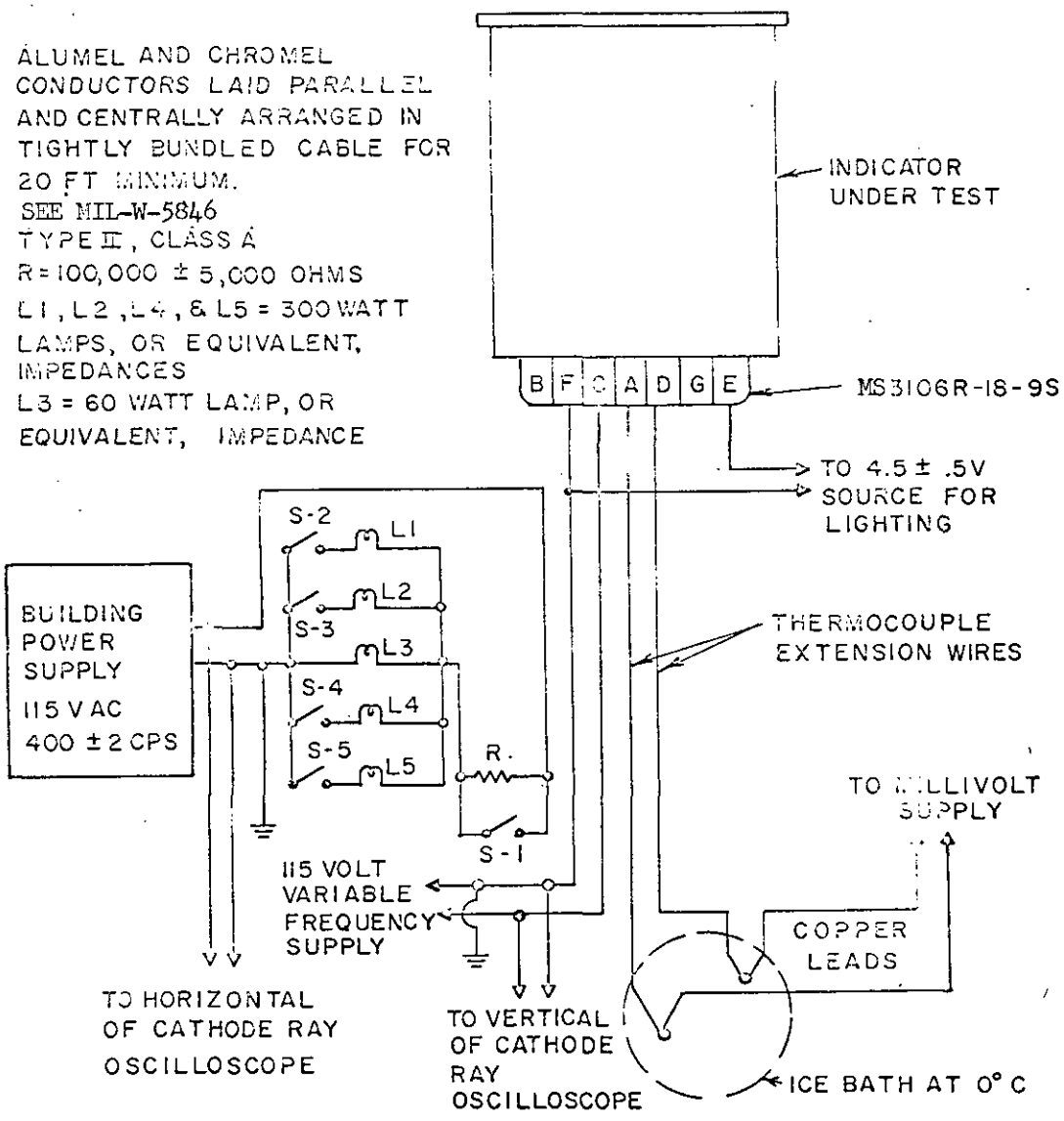


FIGURE 2. Stray signal and beat frequency

4.6.19 High-altitude-low temperature.- The indicator shall be subjected to an absolute pressure equivalent to an altitude of approximately 100,000 feet for a period of 1 hour at a temperature of -55° ±2° C. While still at this pressure and temperature, the indicator shall be subjected to the scale error test specified in 4.6.2. The scale error shall not exceed the tolerances specified in table I for scale error at low temperature. There shall be no damage to the indicator as a result of this test.

4.6.20 Interference control.- Interference and susceptibility tests shall be performed in accordance with MIL-I-6181. The results shall not exceed the values specified therein.

4.6.21 Magnetic effect.- The indicator, first, not operating and second, operating on rated voltage, shall be rotated in a vertical plane about a short bar magnet compass with the nearest part of the indicator 5 ±1/2 inch from and magnetically east or west of the center of the compass. Starting directly under the compass, the indicator shall be held in positions 0, 45, 90, 135, 180, 225, 270, and 315 degrees from the initial position. At each of these positions, the indicator shall be rotated about its own horizontal axis until it is in its normal viewing position. The horizontal magnetic field intensity shall be 0.17 to 0.19 oersted. The deflection of the compass at any of the specified positions shall not exceed 5 degrees. When the indicator is operating, the test point shall be 700° C.

4.6.22 Voltage and frequency variation.- The indicator shall be subjected to the room temperature scale error test (4.6.2) at the 600° and 700° C test points only. The indicator shall then be subjected to any combination of voltages and frequencies ranging from 104 to 126V and 360 to 440 cps at the 600° and 700° C test points. The indication change shall not exceed 3° C.

4.6.23 Thermal shock and fogging.- The indicator shall be subjected to a total of 8 cycles of immersion in tapwater at a temperature of 85° ±2° C and then in tapwater at a temperature of 5° ±2° C. The length of time for each bath immersion shall be 30 minutes with not more than 3 seconds between immersions. During the fourth and eighth cycles at the end of the 30-minute soak in tapwater at 85° C, the indicator shall be removed from the hot bath and within 4 seconds the face of the instrument shall be inserted in the 5° C tapwater to a depth of 3/4 ±1/4 inch. At the end of 1 minute, the indicator shall be withdrawn from the 5° C bath and the cover glass shall be immediately observed for internal fogging. If no fogging is observed, the sequence of the test shall be continued to completion. No evidence of moisture penetration or damage to the enclosure shall result from this test. Following this test, the indicator shall be resubjected to and shall meet the requirements of the sealing test specified in 4.6.4. Fogging of the cover glass during any part of this test shall be cause for rejection.

4.6.24 Cycling of power "OFF" warning.- This test shall be performed prior to installation of the warning in the indicator. The power "OFF" warning shall be operated a total of 20,000 cycles at the rate of 15 ±2 cycles per minute (cpm). A cycle shall consist of operating the warning from the fully off to the fully on position and return to fully off. The distance traveled by the warning mechanism shall be noted before and after testing and shall not differ by more than 1/32 inch. No malfunction shall occur during this test. Twenty-five percent of the cycling shall be at 0° C, 25 percent at room temperature, and 50 percent shall be at 50° C.

4.6.25 Salt spray.- The indicator shall be subjected to a salt spray test in accordance with Procedure I of MIL-E-5272, for a period of 50 hours. The scale error at room temperature test (4.6.2) shall be conducted immediately before and after this test. The scale errors after the salt spray test shall not exceed the tolerances specified for room temperature scale error. Subsequent indicator operation shall not be affected by this test, and excessive corrosion of metal parts, including electrical receptacles, shall be cause for rejection.

4.6.26 Reliability test program.- Thirty days prior to the scheduled date of initiation of testing or at some earlier date, the contractor shall submit a detailed reliability test program to the procuring activity for approval. Testing shall begin only after formal approval of the test program by the procuring activity.

4.6.26.1 Reliability test.- Five sample indicators shall be tested by the contractor for reliability. Only the individual tests shall be conducted on these test samples prior to reliability testing. Duration of the test on each unit, acceptance, permitting production, and the total test hours shall be determined on the basis of the table in MIL-R-26667 entitled "Reliability Accept-Reject Criteria (Method 2)." Recording, data handling, and reporting procedures shall also be in accordance with MIL-R-26667.

4.6.26.2 Reliability test procedure.- The test equipment and fixtures shall include provisions for vibration and temperature cycling at the periodic intervals as specified herein. The vibration double amplitude shall be 0.010 to 0.015 inch with a frequency of 45 to 55 cps. The amplitude and frequency chosen shall provide a vibration level of 1.5g ±10 percent. The direction of vibration is not critical. The indicators shall be subjected to operational cycles consisting of 4 hours of operation with power and millivoltage applied and 30 minutes with power off. The operational cycles shall be conducted at 0° C, room temperature, and 50° C in the following sequence: 4 hours at 0°, 30 minutes off; 4 hours at room temperature, 30 minutes off; 3 hours at 50° C, 30 minutes off, and 4 hours at room temperature, 30 minutes off. During the operating portion of the operational cycle, the millivoltage shall be varied to produce an indication cycle corresponding to a change ranging from 100° to 1,000° C and return to 100° C at a rate of 1.8 ±0.2 cpm. This shall constitute 1 indication cycle. The indication and operational cycles shall be repeated continuously until an accept or reject decision is reached. The continuity of the test may be interrupted for weekend shutdown. During each 4-hour operational cycle, the indicators shall be vibrated for a minimum period of 10 minutes each hour. At 20-hour test intervals during a 30-minute off period, one indicator shall be subjected to the scale error at room temperature test specified herein, so that all indicators are subjected to this test once each 100 hours of testing. The scale errors recorded throughout the test shall not exceed the tolerance specified in table I for scale error during MTBF testing. Upon completion of this test, the indicators shall be subjected to and shall meet the response time and sensitivity tests specified herein. All malfunctions which prevent compliance with the requirements of this specification shall be counted as failures.

4.6.27 Maintainability verification.- Maintainability verification shall be in accordance with the paragraph titled "Maintenance Tast Test and Demonstrations", Appendix A, of MIL-M-26512. The tasks selected shall be adequately demonstrated.

4.6.28 Preservation, packaging, packing, and marking.- Preparation for delivery shall be examined for conformance with section 5.

5. PREPARATION FOR DELIVERY

5.1 Preservation and packaging.-

5.1.1 Level A.- Each indicator shall be preserved in accordance with Method III of MIL-P-116, and packaged in accordance with MIL-P-7936. Electrical receptacles and connections shall be equipped with waterproof plugs and gaskets.

5.1.2 Level C.- Indicators shall be provided sufficient protection against corrosion, deterioration, and physical damage to assure safe delivery, without degradation of indicator reliability, from the supply source to the first receving activity for immediate use.

5.2 Packing.-

5.2.1 Level A.- Indicators preserved and packaged as specified in 5.1.1 shall be packed in exterior-type shipping containers conforming to type I or II, class 2 of PPP-B-636. Insofar as practicable, exterior containers shall be of uniform shape and size and of minimum weight and cube consistent with the protection required. The gross weight of each pack shall not exceed 200 pounds.

5.2.2 Level B.- Indicators, packaged as specified in 5.1.1, shall be packed in domestic-type containers conforming to type I or II, class 1 of PPP-B-636.

5.2.3 Level C.- Indicators requiring overpacking for acceptance by the carrier shall be packed in exterior-type shipping containers in a manner that will insure safe transportation at the lowest rate to the point of delivery. Containers shall meet Uniform Freight Classification Rules or regulations of other common carriers as applicable to the mode of transportation.

5.3 Marking.- Interior and exterior containers shall be marked in accordance with MIL-STD-129. The nomenclature shall be as follows:

INDICATOR, TEMPERATURE, THERMOCOUPLE SELF-BALANCING, POTENTIOMETER TYPE, MS24569- (Applicable dash No.)

6. NOTES

6.1 Intended use.- The indicator covered by this specification is intended for use in indicating the exhaust gas and turbine inlet gas temperature of turbojet and turboprop aircraft engines.

6.1.1 The indicator can be used on instrument panels requiring case mounting in accordance with MS33639 by the application of either an instrument mounting bezel in accordance with MIL-B-6836 or a mounting clamp in accordance with MS28042.

6.2 Ordering data.- Procurement documents should specify the following:

(a) Title, number, and date of this specification.
(b) MS part No. of indicator required (see 1.2).
(c) Data requirements (see 4.3.2 and 4.6.26).
(d) When sampling plan B tests will not be performed (see 4.4.2.2).
(e) Color of background of "OFF" flag (see 3.10).
(f) Applicable levels of packaging and packing (see 5.1 and 5.2).

6.3 Qualification.- With respect to products requiring qualification, awards will be made only for such products as have, prior to the time set for opening of bids, been tested and approved for inclusion in the applicable Qualified Products List whether or not such products have actually been so listed by that date. The attention of suppliers is called to this requirement, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for the Qualified Products List is the Systems Engineering Group, Attn: SEFIP, Wright-Patterson Air Force Base, Ohio 45433, and information pertaining to qualification of products may be obtained from that activity.

Custodians:
Navy - WP
Air Force - (11)

Reviewer activities:
Navy - WP
Air Force - (11)

Preparing activity:
Air Force - (11)

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   A. GIVE PARAGRAPH NUMBER AND WORDING.

   B. RECOMMENDATIONS FOR CORRECTING THE DEFICIENCIES

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3. IS THE DOCUMENT RESTRICTIVE?

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