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MILITARY SPECIFICATION

GAGE, FUEL QUANTITY, CAPACITOR TYPE, UNCOMPENSATED
GENERAL SPECIFICATION FOR

This specification was approved by the Departments of the Army, the Navy, and the Air Force for use of procurement services of the respective Departments.

## 1. SCOPE

1.1 This specification covers the general requirements for uncompensated capacitor type fuel quantity gages.

## 2. APPLICABLE SPECIFICATIONS, OTHER PUBLICATIONS, AND DRAWINGS

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

2.1.1 Specifications.-

Federal

| | |
|---|---|
| QQ-M-151 | Metals; General Specification for Inspection of |
| QQ-P-416 | Plating; Cadmium (Electrodeposited) |

Military

| | |
|---|---|
| MIL-C-5015 | Connectors; Electrical |
| MIL-D-5028 | Drawings and Data Lists; Preparation of (For Engines, Accessories and Other Auxiliary Equipment) |
| MIL-D-5548 | Decalcomanias; Aircraft |
| MIL-F-5572 | Fuel; Aircraft Reciprocating Engine |
| MIL-I-6181 | Interference Limits and Tests; Aircraft Electrical and Electronic Equipment |
| MIL-L-6880 | Lubrication of Aircraft, General Specification for |
| MIL-N-3336 | Nut, Self-Locking, Instrument Mounting |
| MIL-P-5633 | Packaging and Packing of Aircraft Material in Steel Shipping Containers |
| MIL-P-6064 | Packaging of Lightweight Aircraft Accessories |
| MIL-P-6906 | Plates, Information and Identification |
| MIL-S-7742 | Screw Threads, Standard, Aeronautical |
| JAN-1 | Tubes, Electron |
| JAN-C-17 | Cables, Coaxial and Twin-Conductor, for Radio Frequency |
| JAN-C-76 | Cable (Hook-Up Wire), Electronic, Insulated, Radio and Instrument |

Air Force-Navy Aeronautical

| | |
|---|---|
| AN-QQ-A-696 | Anodic-Films; Corrosion-Protective (For) Aluminum Alloys |
| AN-E-19 | Electronic Equipment; General Specification for |

| | |
|---|---|
| AN-L-1 | Luminescent Material; Fluorescent |
| AN-M-13 | Marking, Labeling and Tagging, Aircraft, Aeronautical Equipment, Accessories, Parts, Materials and Supplies |
| AN-P-13 | Preservation and Packaging; Parts and Equipment (General Specification for) |
| AN-P-32 | Plating; Zinc |

2.1.2 Other Publications.-

Air Force-Navy Aeronautical Bulletin

| | |
|---|---|
| No. 143 | Specifications and Standards; Use of |

2.1.3. Drawings.-

Military Standards (Sheet)

| | |
|---|---|
| MS33516 | Case - Standard Dimensions for 3-1/4 Inch Size Instrument |

Air Force-Navy Aeronautical Standard Drawings

| | |
|---|---|
| AN4130 | Fitting - Synthetic Tank Single-Plane Flush and Recessed |
| AND10398 | Metals - Definition of Dissimilar |
| AND10401 | Case - Standard Dimensions for 2-3/4 Dial Instrument (Without Sump) |
| AND10404 | Pointers - Standard Design of Aircraft Instrument |
| AND10412 | Case - 2-Inch Size Instrument, Standard Dimensions for |

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

3. REQUIREMENTS:

3.1 Materials.-

3.1.1 Protective Treatment.- When materials are used in the construction of the gage 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.

3.1.2 Materials shall conform to applicable specifications as specified herein. When materials are used which are not specifically designated, they shall be entirely suitable for the purpose. The use of lightweight materials and weight-saving designs is a major consideration, and their use shall be investigated and exploited to the greatest possible extent.

3.1.3 Metals.- Metals shall be of the corrosion-resisting type or suitably treated to resist corrosion in fuels, salt spray, or atmospheric conditions to which the gage will be subjected when in storage or during normal service use.

3.1.4 Dissimilar Metals.- Unless suitably protected against electrolytic corrosion, dissimilar metals shall not be used in intimate contact with each other. Dissimilar metals are defined by Drawing AND10398.

3.1.5 Nonmagnetic Material.- Nonmagnetic material shall be used for all parts, except where magnetic materials are essential.

3.1.6 Fungus-Proof Materials.- Materials which are not nutrients for fungi shall be used to the greatest extent practicable. Where materials that are nutrients for fungi must be used, such materials shall be treated with a fungicidal agent, as approved by the procuring agency.

3.1.7 Selection of Materials.- Specifications and standards for all materials, parts, and Government certification and approval of processes and equipment, which are not specifically designated herein and which are necessary for the execution of this specification, shall be selected in accordance with ANA Bulletin No. 143, except as provided in the following paragraph.

3.1.7.1 AN or MIL Standard Parts.- AN or MIL Standard parts shall be used wherever they are suitable for the purpose, and shall be identified on the drawing by their part numbers. Commercial utility parts such as screws, bolts, nuts, cotter pins, etc., may be used provided they possess suitable properties and are replaceable by the AN or MIL Standard parts without alteration, and provided the corresponding AN or MIL part numbers are referenced in the parts list and, if practicable, on the contractor's drawings. In the event there is no suitable corresponding AN or MIL Standard part in effect on date of invitation for bids, commercial parts may be used provided they conform to all requirements of this specification.

3.2 Design and Construction.-

3.2.1 The basic gage shall be designed to indicate the liquid quantity in a given fuel tank by measurement of the electrical capacitance between two or more plates of an electrostatic capacitor mounted in the tank. It shall consist essentially of one or more tank units, an indicating unit, and an intermediate device for transmitting the indication of liquid quantity registered by the tank unit or units to the indicating unit. The intermediate device shall consist of a suitable power unit (alternating current bridge and amplifier). The basic gage design shall provide linear indication. The design shall also provide an output signal for totalization purposes, if required for specific applications as directed by the procuring agency. Incorporation of the added totalization feature shall entail the inclusion of a suitable intermediate power unit and an indicating unit which shall be designed to indicate the total amount of fuel registered by the individual gages. The tank unit or units shall be so characterized that a constant capacitance is registered for each unit volume of fuel sensed.

3.2.2 The gages shall be so constructed that no parts will work loose in service. They shall be built to withstand the strains, jars, vibrations, and other conditions incident to shipping, storage, installation, and service. Pivots, bearings, and gears shall neither bind nor shake and shall be as near frictionless as practicable.

3.2.3 Fire Hazard.- The electrical circuit of the gage system shall be so designed that the value and magnitude of the potentials applied to the tank unit or units, shall not create a fire hazard in the airplane fuel tank.

3.2.4 General.- The requirements of this specification are generally applicable to all types of aircraft installations wherein reciprocating engines are used. However, due to the wide variations of fuel tank capacities, arrangements, and numbers, specific details such as length of tank unit, arrangement of calibration of scales, et cetera, shall be supplied by drawings or part number. The detail requirements shall be based upon the general requirements of this specification.

3.3 Performance.- The gage shall satisfactorily meet the requirements specified in Section 4, when subjected to the applicable tests.

3.4 Interchangeability.- All parts having the same manufacturer's part number shall be directly and completely interchangeable with each other with respect to installation and performance. Changes in manufacturer's part numbers shall be governed by the drawing number requirements of Specification MIL-D-5028.

3.5 Component Parts.- The gage shall consist of one or more characterized type tank units, an intermediate device, an indicator, and associated connecting cables. The design shall provide linear indication.

3.5.1 Totalizer.- The totalizer shall consist basically of an intermediate device and an indicator and shall by electrical means sum the indications of two or more individual linear indicating gages. The individual gages associated with the totalizing gage system shall be designed to provide suitable electrical output signals for summation by the totalizer. Malfunctioning of the totalizer shall not adversely affect the performance of the individual linear indicating gages.

3.5.2 Component parts of two or more individual gages shall not be housed in a single unit. The number of units shall be kept to a minimum. Similar units of two or more gages may be mounted on the same rack subject to approval by the procuring agency.

3.5.3 Tank Units.- The basic tank unit shall consist of a suitable capacitative arrangement of metallic conductors such as a pair of concentric cylinders electrically insulated from each other and forming a three-wire capacitor. The design shall be such that the tank unit can be disassembled and reassembled without the use of special tools. It shall be so constructed as to permit fuel into which the unit has been immersed to rise freely to its natural level between the conductors, in order that up to this level, the fuel will serve as the dielectric substance. Above the level of the fuel, a mixture of air and vapor will be the dielectric substance. Nonsensing portions of the sensing element shall not exceed the following dimensions: 0.600 inch at the flange end and 0.400 inch at the opposite end for external mounted tank units, and 0.400 inch at both ends for internal mounted tank units. It shall be so constructed as to preclude the formation of deposits and sediments between the conductors. The minimum allowable distance between the conductors shall be 0.125 inch. The tank unit shall be designed to make electrical connections readily accessible for testing the tank unit and making calibration adjustments using a substitute precision capacitance. The materials used in the construction of the tank units shall be impervious to aircraft fuels.

3.5.3.1 Characterized Tank Units.- Characterized tank units shall be designed to provide a linear relationship between the electrical capacitance and the volume of fuel sensed. The basic design shall be suitable for producing high capacitance ratios (i.e., large ratio between the maximum and minimum capacitance per unit length) and following calibration curves with a high degree of accuracy. The basic design shall possess good production adaptability. The size and weight shall be kept to the minimum consistent with high quality aircraft instrument design.

3.5.3.2 Mounting Types.- The tank unit designs shall include external top mounted types, external bottom mounted types, internal mounted types, and other types as required for specific installations.

3.5.3.3 Mounting Flange.- The external top and bottom mounted types shall be designed and constructed for installation in a fuel tank fitting which has dimensions conforming to Drawing AN4130, size 6, or as otherwise specified by the procuring agency. The means provided for mounting the internal mounted tank unit types shall be entirely suitable for the purpose and shall be subject to approval by the procuring agency.

3.5.3.4 Connector Housing.- For externally mounted type tank units, the projection of the connector housing beyond the flange surface shall be held to a minimum practicable distance in order to facilitate mounting.

3.5.3.5 Seal.- The external mounting type tank unit connector head shall be an inclosed compartment sealed to prevent the entrance of fuel and moisture.

3.5.4 Intermediate Device.- The intermediate device shall include all parts of the gage exclusive of the tank units, the indicator, and the external wiring. The intermediate device shall incorporate adjustment features to permit universal application without substitution of component parts of the device.

3.5.4.1 Standard Electronic Parts.- Electronic parts and the application thereof, shall be in accordance with Specification AN-E-19.

3.5.4.2 Vacuum Tubes.- Vacuum tubes shall be of approved ruggedized construction conforming to Specification JAN-1.

3.5.4.3 Chassis.- The chassis for electronic devices such as amplifiers shall be of metal and shall be designed to form a rigid support for the equipment mounted thereon.

3.5.4.4 Inclosures.- Amplifiers, bridge units, or other electronic assemblies shall be inclosed and sealed sufficiently to protect the internal parts from changeable climatic and atmospheric conditions and shall meet the test requirements specified herein.

3.5.4.5 Mounting Bases.- Each separate component of the intermediate device shall be provided with a suitable mounting base.

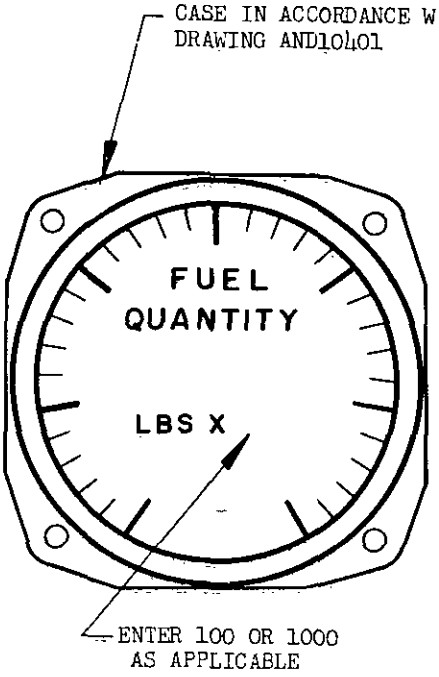
3.5.4.6 Vibration and Shock Insulation.- Delicate devices, such as vacuum tubes, or other parts whose life or performance would be adversely affected by shock and vibration shall be protected from shock and vibration occurring in any direction either by the mounting of the article of equipment itself or by local cushioning of such devices. In cushioning, all mountings shall be so designed and installed as to be readily replaceable without major disassembly. If cushioning is employed, sufficient clearance shall be provided between parts to preclude the possibility of a cushioned part striking any other part under conditions of a violent shock.

3.5.5 Indicators.-

3.5.5.1 The indicator shall be an electrical receiver which continuously indicates the quantity of fuel in pounds. The indicator designs shall conform to the sensitive and nonsensitive dial presentation types shown on figures 1, 2, and 3. Stops shall be provided on all indicators to prevent the main pointer from making more than one complete revolution. Provision shall be incorporated in the design to permit the addition of level warning switching mechanisms and output signal controls such as potentiometers as required for specific applications.

3.5.5.2 Indicator Case.- The indicator case designs shall be in accordance with those shown on figures 1, 2, and 3. The case shall be constructed of a suitable material applicable to hermetic sealing, and the material shall be uniform in texture with a smooth external surface. The case shall provide a hermetically sealed enclosure for the internal mechanism of the indicator. The design of the indicator case shall be such that the internal mechanism may be removed from the case, replaced, and the case resealed. This shall be accomplished without the use of special tools and fixtures, unless they are approved by the procuring agency. The hermetic sealing shall be so accomplished that the seal will not be dependent upon materials which will be affected by the action of any atmosphere to which the indicator may be subjected.

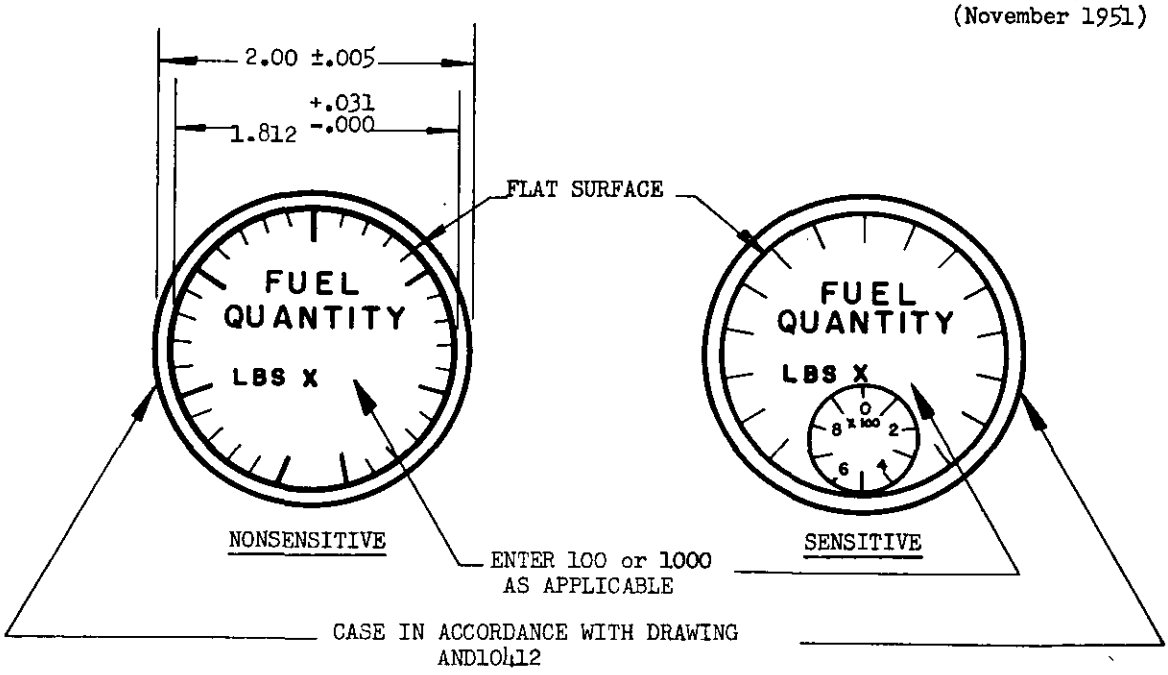
3.5.5.2.1 The cases shall be filled with helium of at least 98-percent purity, free of dust particles, and containing not more than 0.006 milligram of water vapor per liter (dewpoint -65°C) at the filling pressure. The absolute pressure of the helium in the case shall be approximately one atmosphere.



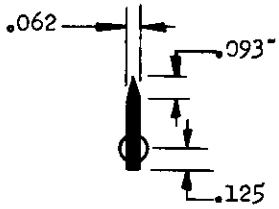

LENGTH OF CASE SHALL NOT EXCEED 4.25 INCHES

| MARKINGS | HEIGHT OR LENGTH ±.010 | WIDTH OF LINE OR GRADUATION ±.005 | MATERIAL OR FINISH |
|---|---|---|---|
| MAJOR GRADUATIONS LBS X FUEL QUANTITY | .250<br>.125<br>.156 | .031<br>.016<br>.031 | FLUORESCENT-LUMINESCENT MATERIAL |
| MINOR GRADUATIONS | .156 | .020 | |
| BACKGROUND OF DIAL | - - | - - | DURABLE DULL BLACK |

FIGURE 1.




DIMENSIONS IN INCHES UNLESS OTHERWISE SPECIFIED TOLERANCES: ANGLES ±0°15'
DECIMALS ±.005




SUB-DIAL POINTER

NOTE: LENGTH OF CASE SHALL NOT EXCEED 5 INCHES

| MARKINGS | HEIGHT OR LENGTH ±.010 | WIDTH OF LINE OR GRADUATION ±.005 | MATERIAL OR FINISH |
|---|---|---|---|
| MAIN DIAL: | | | FLUORESCENT-LUMINESCENT MATERIAL |
| NUMERALS | .140 | .025 | |
| FUEL QUANTITY | .140 | .020 | |
| MAJOR GRAD | .188 | .031 | |
| MINOR GRAD | .125 | .015 | |
| LBS X | .100 | .015 | |
| SUB-DIAL: | | | |
| NUMERALS | .100 | .015 | |
| MAJOR GRAD | .094 | .010 | |
| MINOR GRAD | .062 | .010 | |
| "X100" | .046 | .010 | |
| CIRCLE DIA | .718 | .015 | |
| BACKGROUND OF DIAL | - - - | - - - | DURABLE DULL BLACK |

FIGURE 2.

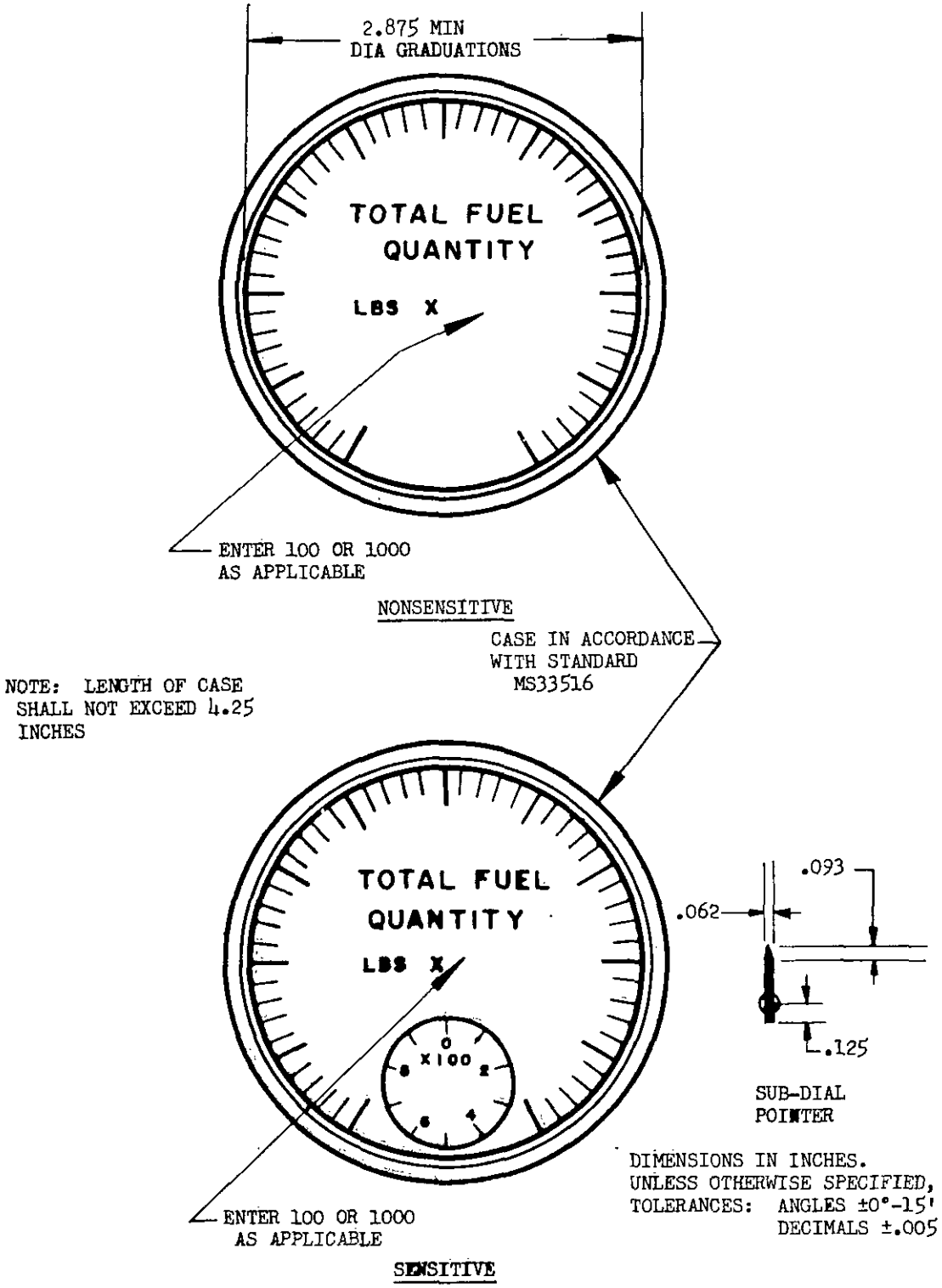



FIGURE 3.

3.5.5.3 Bezel Ring.- The bezel ring, used with the indicator design shown on figure 1, shall be made of nonferrous low density metal and shall have a durable dull black finish.

3.5.5.4 Cover Glass.- The cover glass shall be suitable for hermetic sealing and shall be clear, flat, and free from flaws which interfere with the normal reading of the instrument. The thickness of the cover glass shall be the minimum practicable and entirely suitable for the purpose intended.

3.5.5.5 Dial.- The indicator dial shall be made of aluminum, and shall be fastened securely to the case or upon the frame of the mechanism of the indicator by not less than two screws in such a manner that it will not loosen or turn when the instrument is vibrated. For sub-dial sensitive indicators of the types shown in figures 2 and 3, the inner portion of the sub-dial shall be recessed a sufficient distance, in order that the outer surface of the pointer will be on the same plane as the numerals placed on the main dial.

3.5.5.5.1 Dial and Cover Glass Location.- The distance between the front surface of the bezel and the outside surface of the cover glass shall not exceed 0.062 inch. The distance between the inside surface of the cover glass and the dial shall not exceed 0.125 inch.

3.5.5.5.2 Dial Scale.- The dial scale shall be graduated and numbered to indicate quantities in pounds at even intervals. The intervals employed shall be determined by the capacity of the tank and the scale length, in order to obtain a scale having sufficient graduations and numerals for each reading without overcrowding. For nonsensitive type indicators, the indicating scale shall provide a minimum scale radius of 320 degrees. The main indicating scale for sub-dial sensitive type indicators shall provide a minimum scale radius of 255 degrees.

3.5.5.5.3 The dial scale shall be marked according to the following procedure:

(a) Indicator dials shall be calibrated in pounds.
(b) The dial graduations shall be uniformly spaced.
(c) The end point of the calibration shall be the number of pounds obtained by multiplying the usable tank volume in gallons by a density of 6.593 pounds per gallon.
(d) The scale end shall be the last division before the end point, (for example, if the weight of fuel at the end point is 4,480 lb and the minor graduations represent 200 lb the scale end will be the minor graduation representing 4,400 lb).

3.5.5.5.4 Dial Markings.- All markings shall be durable to withstand usage encountered in service. The dials shall be marked as shown on figures 1, 2, and 3. The graduation markings shall be linear within ±0°20' of arc for indicators conforming to figures 1 and 3, and within ±0°30' for indicators conforming to figure 2. Wherever practicable, each major graduation shall be identified by a single numeral.

3.5.5.5.4.1 Marking dimensions for the indicator dial shown on figure 3 shall be in accordance with the following table:

| Markings | Height or Length Inch ±0.010 | Width of Line or Graduation Inch ±0.005 | Material or Finish |
|---|---|---|---|
| MAIN DIAL | | | |
| Numerals | 0.180 | 0.031 | |
| Total Fuel Quantity | 0.140 | 0.025 | Fluorescent |
| Fuel Quan. (as applicable) | 0.156 | 0.031 | Luminescent |
| Major Graduation | 0.250 | 0.031 | |
| Minor Graduation | 0.188 | 0.015 | |
| LBS-X- | 0.100 | 0.015 | |
| SUB-DIAL | | | |
| Numerals | 0.100 | 0.015 | |
| Graduations | 0.094 | 0.010 | Fluorescent |
| X100 or 1000 (as applicable) | 0.062 | 0.010 | Luminescent |
| Circle Diameter | 0.906 | 0.015 | |
| Background of Dial | - - - | - - - | Durable Dull Black |

3.5.5.5.4.2 Fluorescent-Luminescent Material.- Fluorescent-luminescent material shall conform to Specification AN-L-1.

3.5.5.6 Pointers.- Unless otherwise specified herein, pointers for the indicators shall conform to AND10404-8. Pointers shall be light and sufficiently rigid to prevent oscillation under vibration. They shall be firmly attached to the associated mechanism.

3.5.5.6.1 Pointer Length.- The pointer length shall be such that the pointer tip will extend into the scale a distance equal to 1/3 to 2/3 of the length of the shortest graduation.

3.6 Electrical Cable.- Hook-up wire and external unshielded connector cable shall be in accordance with Specification JAN-C-76. Coaxial cable shall be in accordance with Specification JAN-C-17. Electrical cable used within the fuel tank and subject to the action of the fuel shall be entirely suitable for the purpose intended. In applications where the temperature may exceed 90°C in compartments of the aircraft structure through which the electrical interconnecting cables will be routed, the cables shall be specially designed for high temperature use and shall be subject to approval of the procuring agency. Internal wiring shall be neat and accomplished in a manner that individual wires may be easily traced. Wires shall be tied to the terminals prior to soldering where practicable.

3.6.1 Cable Length.- Accuracy and sensitivity of the gage shall not be adversely affected by increasing or decreasing the tank unit interconnecting cables within the limits of from 5 to 100 feet.

3.7 Electrical Connectors.- The electrical connectors used, with the exception of those required for the tank unit circuits, shall be in accordance with Specification MIL-C-5015, unless otherwise approved by the procuring agency. Coaxial cable connectors and other types of connectors or methods of connection used on tank unit assembly shall be suitable for the purpose intended and shall be subject to approval by the procuring agency. The connectors provided for interconnecting externally the complete tank unit assembly shall be polarized at each point of connection.

3.8 Input Electrical Power.- The gage shall be designed to operate from a 115V, 400-cycle, single-phase a-c power supply. Transfer relays which may be required for specific installations may be operated from a 28V d-c power source subject to approval of the procuring agency.

3.9 Damping.- Sufficient damping shall be provided in the gage assembly to eliminate excessive oscillation and provide steady indication of the pointer. Gages employing sensitive type indicators shall be designed to provide practically "dead-beat" operation.

3.10 Calibration Adjustment.- Means shall be provided for adjusting the electrical circuit for range and calibration of the indicator. Adjustments of the indicator pointer shall be such that a change in the full adjustment does not appreciably affect the position of the indicator pointer at the zero point. The adjustments shall be located in the intermediate device and not in the tank units or indicator. The adjustments shall be of sufficient range to compensate for all manufacturing tolerances in the gage and the fuel tanks, and shall provide a sensitivity such that adjustments can be easily accomplished under service operations. The design shall be such that the complete gage including the compensator can be accurately and easily checked when the gage is installed in the airplane, by means of suitable test equipment.

3.11 Gage Failure Indication.- The gage shall be provided with a readily accessible test button to indicate failure of the gage operation. The test button, when depressed, shall cause the gage indication to decrease until the lower stop is reached. When the button is released the gage indication shall return to normal. The test button shall be designed to be mounted as a separate item and shall be subject to approval by the procuring agency.

3.12 Screw Threads.- Unless otherwise specified, the threads of all machine screws, 0.060 inch or larger in diameter, shall conform to Specification MIL-S-7742.

3.13 Lubrication.- Lubrication shall be accomplished in accordance with Specification MIL-L-6880. Lubricants shall conform to applicable Government specifications, unless otherwise approved by the procuring agency.

3.14 Finishes and Protective Coatings.-

3.14.1 Finishes and protective coatings which will crack, chip, or scale during normal service life or due to extremes of atmospheric conditions, shall not be used.

3.14.2 Aluminum-Alloy Parts.- Aluminum-alloy parts, where practicable, shall be covered with an anodic film conforming to Specification AN-QQ-A-696.

3.14.3 Steel Parts.- Steel parts shall be cadmium- or zinc-plated where practicable in accordance with Specification QQ-P-416, type II or III, as applicable, and of a class that is adequate to achieve the degree of protection required, or Specification AN-P-32.

3.15 Identification of Product.-

3.15.1 Nameplate.- Nameplates conforming to Specification MIL-P-6906 shall be securely attached to each separately mounted unit of the gage and shall be legibly and permanently marked with the information listed below. The information marked in the spaces provided on the nameplate shall be in accordance with Specification AN-M-13.

INDICATOR (or Tank Unit, Power Unit, Amplifier, etc., as applicable) for
GAGE, FUEL QUANTITY, CAPACITOR TYPE
115V, 400-Cycle, Single-Phase, AC_____ Amp (Applies only to Power Input Unit)

Specification MIL-G-7817
Manufacturer's Part No.
Manufacturer's Serial No.
Stock No. (USAF or Navy, as applicable)
Contract or Order No.
Manufacturer's Name or Trade-Mark
U S Property

3.15.2 Use of AN or MIL Designations.- AN or MIL designations shall not be applied to a product, except for Qualification test samples, nor referred to in correspondence or sales matter, until notification has been received from the Aeronautical Standards Group that the product has been approved for aeronautical use, by both the Air Force and the Bureau of Aeronautics.

3.16 Installation.-

3.16.1 Installation Instructions.- For Navy procurement only, the contractor shall furnish with each instrument one printed copy of instructions, with illustrations and diagrams if necessary, covering the installation of the instrument. Prior to printing, two copies shall be furnished to the qualifying agency for approval. Whenever possible, the instructions shall be arranged to require only one sheet of paper, either 8-1/2 by 11 inches or 17 by 11 inches.

3.16.2 Mounting Screws.- The contractor shall furnish sufficient mounting screws for installing indicators conforming to figure 1. The indicator mounting screws shall be No. 6-32, NC-2 round head brass machine screws having a durable dull black finish. Lengths shall be sufficient for mounting on a panel 3/16 inch thick.

3.16.3 Removable Spring Nuts.- For indicators conforming to figure 1, the contractor shall furnish a sufficient number of removable No. 6-32, NC-2 spring nuts to fit the mounting lugs of the indicator, of a type conforming to Specification MIL-N-3336.

3.16.4 Wiring Diagram.- A wiring diagram showing the external electrical connections of the basic circuit, point to point between all the basic components of the gage, insofar as practicable, shall be permanently affixed to the inside of the intermediate device or affixed to the mounting unit. The wiring of the tank unit assembly shall be shown in such a manner as to make the diagram applicable regardless of the number of tank units used. An internal wiring diagram of each of the individual units of the fuel gage shall be permanently affixed on or within the unit where practicable. If decalcomanias are used for this application, they shall conform to Specification MIL-D-5548.

3.16.5 Envelope.- When applicable, an envelope furnished by the contractor shall be packaged with each indicator. The envelope shall contain the installation instructions, mounting screws and/or removable spring nuts as required. Each envelope shall be marked with the applicable portions of the following information:

"IMPORTANT
THIS ENVELOPE CONTAINS MOUNTING SCREWS, SPRING NUTS AND
INSTALLATION INSTRUCTIONS"

3.17 Workmanship.-

3.17.1 General.- The gage, including all parts and accessories shall be constructed and finished in a thoroughly workmanlike manner. Particular attention shall be given to neatness and thoroughness of soldering, wiring, marking of parts and assemblies, welding and brazing, painting, riveting, machine-screw assemblies, and freedom of parts from burrs and sharp edges.

3.17.2 Screw Assemblies.- Assembly screws and bolts shall be tight. The word "tight" means that the screw or bolt cannot be appreciably tightened further, without damage or injury to the screw or bolt or threads.

3.17.3 Riveting.- Riveting operations shall be carefully performed to insure that the rivets are tight and satisfactorily headed.

3.17.4 Gears.- Gear assemblies shall be properly alined and meshed, and shall be operable without interference, tight spots, loose spots, or other irregularities. Where required, gear assemblies shall be free from backlash.

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

## 4. SAMPLING, INSPECTION, AND TEST PROCEDURES

4.1 Classification of Tests.- The inspection and testing of gages shall be classified as follows:

(a) Qualification tests: Qualification tests are those tests accomplished on samples submitted for qualification as a satisfactory product.

(b) Inspection tests: Inspection tests are those tests accomplished on gages manufactured and submitted for acceptance under contract.

4.2 Test Conditions.-

4.2.1 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.

4.2.2 Position.- Unless otherwise specified, the indicator shall be tested with the dial in the normal operating position.

4.2.3 Test Power.- Unless otherwise specified herein, the gages shall be tested with 115V, 400-cycle, single-phase, a-c power supply. The voltage and frequency tolerance shall be ±2 percent. All tank unit capacitance measurements shall be made at 400 cycles per second.

4.2.4 Master Test Standards.-

4.2.4.1 Test Instrument.- Whenever a master test instrument is specified it shall be in the form of a precision variable capacitor, or a precision fixed capacitor or capacitors, precision voltage source, and/or a precision resistance decade, as applicable. The accuracy of the precision capacitors, fixed or variable, shall be 0.2 percent or 0.2 uuf, whichever is the greater, at a temperature of 25°C. The accuracy of the precision resistance decade and/or voltage source shall be 0.1 percent at a temperature of 25°C.

4.2.4.2 Capacitance Bridge.- The master capacitance bridge specified herein shall be used to measure the capacitance of tank units and/or compensator sensing units. The accuracy of the bridge shall be 0.2 percent, or 0.2 uuf, whichever is the greater, at an ambient temperature of 25°C. The accuracy of the bridge shall be based on Bureau of Standards certification.

4.2.5 Nominal Fuel.- Nominal fuel, as specified herein, shall be a suitable fuel having a dielectric constant of 1.990 and a density of 6.000 lb/gal.

4.2.6 Gage accuracies and tolerances specified herein are applicable to the gage only and do not include accuracy tolerances of test equipment.

4.3 Qualification Tests.-

4.3.1 Sampling Instructions.- The Qualification test samples shall consist of two complete gages and totalizers upon which qualification is desired. Each of the two gages shall be supplied with one tank unit having a capacitance distribution as specified in table I and an indicator as described in paragraph 4.3.1.1. Two supplemental tank units, having a capacitance distribution as specified in table I shall also be furnished. Samples shall be identified as required and forwarded to the agency designated in the Letter of Authorization from the qualifying agency. (See paragraph 6.3.)

4.3.1.1 Indicator.- The main dial of the indicator shall be graduated from 0 to 100 percent. On the nonsensitive indicator the 100-percent graduation shall be at approximately 320 degrees. On the sensitive indicator the 100-percent graduation shall be at approximately 270 degrees, and the sub-dial shall be graduated in 10 equal increments each being equal to 1 percent on the main dial. The 91-percent point shall correspond to complete immersion of the tank unit in nominal fuel having a dielectric constant of 1.990.

4.3.1.2 Totalizer.- Qualification approval of totalizers shall be given only in conjunction with gages submitted and tested in accordance with the requirements of this specification. The totalizer shall be designed to combine the indications of three gages corresponding to relative tank volumes of 6:3:1. The requirements for the totalizer indicator shall be the same as those for the gage indicator.

4.3.1.2.1 Gage Outputs for Totalizer.- When submitted in conjunction with totalizers, the gages shall be provided with means for supplying signals suitable for application to the totalizers. The signals shall be of two ranges, corresponding to relative tank volumes of 6:1. One of the two gages shall supply signals of one range, and the other shall supply signals of the other range.

4.3.1.2.2 Totalizer Inputs.- When requested by the qualifying agency, the manufacturer shall furnish with the totalizer a set of three devices capable of supplying input signals suitable for testing the totalizer. These devices may be actual fuel quantity gages (distinct from the qualification sample) or artificial devices simulating the output characteristics of the gages. If artificial devices are supplied, the qualifying agency may conduct such tests as are required to verify that the signals produced by such devices are equivalent to the signals produced by actual gages.

4.3.1.3 Wiring Diagrams.- The manufacturer shall submit complete wiring diagrams of all the equipment on which qualification is desired. The wiring diagram shall include values of components.

4.3.1.4 Calibration Data for Qualification Tests.- The gage manufacturer shall furnish the Qualification test agency, on 8 x 10-1/2 inch paper, two copies of Calibration Data containing the following information:

(a) Data for both the gage tank unit and the supplemental tank unit.

  (1) Distance from bottom surface of mounting flange to top of sensing portion and distance from bottom of sensing portion to bottom of tank unit, (length of nonsensing portion at both ends of tank unit for internally mounted units).
  (2) Dry capacitance.
  (3) Total capacitance for complete immersion in nominal fuel.

(b) Output voltage and/or resistance values for totalizer (where applicable) corresponding to full scale indication (i.e., 100 percent).

TABLE I
Characterization of Tank Units for Qualification Tests

| GAGE TANK UNIT | | | SUPPLEMENTAL TANK UNIT | | | |
|---|---|---|---|---|---|---|
| Distance of Fuel Level below Top of Sensing Portion (Inches) | Dry Capacitance per Unit Length (Relative Units) | Increase over Dry Capacitance (Percent of Total) | Indicator Reading (Percent of Full Scale) 1/ | Distance of Fuel Level below Top of Sensing Portion (Inches) | Dry Capacitance per Unit Length (Relative Units) | Increase over Dry Capacitance (Percent of Total) |
| 0 | 3.5 | 100.0 | 91.00 | 0 | 0.4 | 100.0 |
| 1 | 3.5 | 96.5 | 87.82 | 2 | 0.8 | 98.8 |
| 2 | 3.5 | 93.0 | 84.63 | 4 | 1.2 | 96.8 |
| 3 | 3.5 | 89.5 | 81.44 | 6 | 1.6 | 94.0 |
| 4 | 3.5 | 86.0 | 78.26 | 8 | 2.0 | 90.4 |
| 5 | 3.5 | 82.5 | 75.08 | 10 | 2.4 | 86.0 |
| 6 | 3.5 | 79.0 | 71.89 | 12 | 2.8 | 80.8 |
| 7 | 3.5 | 75.5 | 68.70 | 14 | 3.2 | 74.8 |
| 8 | 3.5 - 7.5 | 72.0 | 65.52 | 16 | 3.6 | 68.0 |
| 9 | 7.125 | 64.69 | 58.87 | 18 | 4.0 | 60.4 |
| 10 | 6.750 | 57.75 | 52.55 | 20 | 3.6 | 52.8 |
| 11 | 6.375 | 51.19 | 46.58 | 22 | 3.2 | 46.0 |
| 12 | 6.000 | 45.00 | 40.95 | 24 | 2.8 | 40.0 |
| 13 | 5.625 | 39.19 | 35.66 | 26 | 2.4 | 34.8 |
| 14 | 5.250 | 33.75 | 30.71 | 28 | 2.0 | 30.4 |
| 15 | 4.875 | 28.69 | 26.11 | 30 | 1.6 | 26.8 |
| 16 | 4.500 | 24.00 | 21.84 | 32 | 1.2 | 24.0 |
| 17 | 4.125 | 19.69 | 17.92 | 34 | 0.8 | 22.0 |
| 18 | 3.750 | 15.75 | 14.33 | 36 | 0.4 | 20.8 |
| 19 | 3.375 | 12.19 | 11.09 | 38 | 0.4 | 20.0 |
| 20 | 3.000 | 9.00 | 8.19 | 40 | 0.4 - 2.4 | 19.2 |
| 21 | 2.625 | 6.19 | 5.63 | 42 | 2.4 | 14.4 |
| 22 | 2.250 | 3.75 | 3.41 | 44 | 2.4 | 9.6 |
| 23 | 1.875 | 1.69 | 1.54 | 46 | 2.4 | 4.8 |
| 24 | 1.500 | 0 | 0 | 48 | 0 | 0 |

1/ This column lists the required indicator readings when the tank unit is connected into the gage circuit and the sensing portion of the tank unit is immersed to the specified depths in nominal fuel of dielectric constant 1.990.

4.3.2 Tests.- The Qualification tests shall consist of all the tests of this specification. The tests shall be conducted in the following sequence: Individual tests, Sampling tests, and Special tests. Qualification tests may, at the option of the qualifying agency, be supplemented by actual installation and flight tests in aircraft.

4.4 Inspection Tests.- The contractor shall furnish all samples and shall be responsible for accomplishing the required tests. When inspection is conducted at the contractor's plant, all inspection and testing shall be under the supervision of the Government Inspector. Contractors not having laboratory testing facilities satisfactory to the Government shall engage the services of a commercial testing laboratory acceptable to

the procuring agency. The contractor shall make available test reports showing quantitative results for all tests required by this specification, and signed by an authorized representative of the contractor or laboratory, as applicable. Acceptance or approval of material during course of manufacture shall in no case be construed as a guaranty of the acceptance of the finished product.

4.4.1 Calibration Data for Inspection Tests.- The gage manufacturer shall furnish the Government Inspector, on 8 x 10-1/2 inch paper, two copies of Calibration Data containing the following information:

(a) Type of Airplane_____Series_____
(b) Tank or Tanks for which calibration applies
(c) Fuel Gage System No._____Cabling Diagram_____
(d) List of all components of the gage system with the manufacturer's part numbers
(e) The manufacturer's Part Nos. and dry capacitances of all individual tank units
(f) Data for tank unit assembly
  (1) Dry capacitance
  (2) Total capacitance for complete immersion in nominal fuel.
  (3) Added capacitance due to complete immersion in nominal fuel
(g) Relative heights of tank units corresponding to locations in airplane (elevation of bottom of each tank unit relative to bottom of lowest tank unit)
(h) Data for Indicator Dial Calibration
  (1) Pounds of Fuel Equivalent to Full Scale Indication
  (2) Pounds of Fuel Equivalent to Nominal Full Indication
(i) Tables II and III, herein.
(j) Table IV, where applicable, herein.

TABLE II

Individual Tank Unit Calibration Data

| Height of Fuel Level in Inches from Bottom of Tank Unit | Added Capacitance Attributable to Fuel, Expressed in Percent of Total Added Capacitance for Complete Immersion | | |
|---|---|---|---|
| | Tank Unit No. 1 | Tank Unit No. 2 | Additional Tank Units, as Applicable |
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TABLE III

Gage System Calibration Data

| Height of Fuel Level in Inches from Bottom of Lowest Tank Unit | Total Tank Unit Capacitance for Nominal Fuel, uuf | Indicator Reading in Pounds (All Major Dial Graduations) | Output Voltage and/or Resistance (Applicable to Gages Which Are a Part of a Totalizing Gage System) |
|---|---|---|---|
| | | | |

NOTE: This table shall be extended to include capacitance values and totalizer output values up to and including the highest major dial graduation.

TABLE IV

Totalizing Gage Calibration Data
(Intermediate Device and Indicator)

| Input Voltage and/or Resistance Values | Indication in Pounds of Fuel Throughout Complete Scale |
|---|---|
| | |

4.4.2 Individual Tests.- In the order specified, each gage shall be subjected to the following tests.

4.4.2.1 Examination of Product.- Each gage shall be examined to determine compliance with the requirements specified herein with respect to materials, workmanship, and marking.

4.4.2.2 Indicator Operation at Room Temperature.- All individual and totalizer indicators identified by the same manufacturer's part number shall be individually checked against fixed design calibration data to determine:

(a) That the scale error at each major graduation is within ±1/2 percent of full scale. The scale error of each indicator shall be determined under conditions of both increasing and decreasing readings.

(b) That the pointer will travel from zero to full scale indication in 1 minute or less for nonsensitive type indicators and 2 minutes or less for sensitive type indicators.

(c) That the output voltage or resistance values at each major graduation are within ±1/2 percent of the fixed design voltage or resistance values at full scale. This test is required only for those indicators providing signals for totalizers.

(d) That level switching mechanisms and other items such as potentiometers incorporated in the design for specific applications operate properly.

(e) That the pointer moves smoothly over the complete range of the indicator and that the stops are located to permit the pointer to rotate at least 10 degrees past the 0 and end points.

4.4.2.3 Intermediate Device Operation at Room Temperature.- All intermediate devices associated with individual gages and totalizers identified by the same manufacturer's part number shall be individually checked against fixed design calibration data to determine:

(a) That the empty and full adjustments function correctly.

(b) That all adjustments associated with compensation are properly set.

(c) That the dead spot shall not exceed 0.2 percent at any two points selected by the Inspector. The dead spot shall be determined as follows: The input capacitance (or voltage and/or resistance, as applicable) of the gage system shall be slowly varied by means of the master test instrument, first in one direction and then in the other. The capacitance change required to produce indicator rotation shall be noted and shall be computed as a percentage of the total input capacitance range for which the gage is calibrated; this percentage is defined as the dead spot.

4.4.2.4 Tank Unit Electrical Capacitance.- The dry capacitance of each tank unit shall be determined by means of the master capacitance bridge. The capacitance value established shall not differ from the respective value specified by the manufacturer by more than 1.0 percent. This test may be combined with the Tank Unit Calibration test.

4.4.2.5 Tank Unit Leakage.- Tank units of the externally mounted type shall be installed in a suitable pressure chamber equipped with the proper size flange fittings. A pressure of 30 ±5 psi shall be applied within the pressure chamber, and no leak shall be detected on the outer side of the tank unit mounting flange and connector head assembly. A suitable liquid shall be used for detecting the presence of air bubbles. The duration of this test shall be 5 minutes. A leak shall be defined as a periodic bubbling from a specific area at a frequency of at least one bubble each minute.

4.4.2.6 Tank Unit Calibration.- The empty capacitance of each of the tank units shall be determined by means of the master capacitance bridge. Each of the tank units shall be individually immersed in a representative fuel sample to the levels specified in table I or table II, as applicable, and the added capacitance attributable to the fuel shall be determined. The added capacitance values, expressed as percentages of the total added capacitance for complete immersion, shall agree within 1.5 percent with the values specified in table I or table II, as applicable.

4.4.2.7 Sealing.- Hermetically sealed components of the gage, such as indicators, amplifiers, power units, et cetera, shall be immersed in a suitable liquid, such as water, within an inclosure and the absolute pressure within the inclosure reduced to approximately 1 inch Hg and maintained for 1 minute, or until air bubbles cease to be given off by the liquid, whichever is longer. The absolute pressure within the inclosure shall then be increased to 2.5 inches Hg. Bubbles emanating from the interior of the item shall be cause for rejection. Bubbles which are the result of entrapped air on the various exterior parts of the case and/or housing shall not be considered as a leak. Other methods of leak test which produce equal or greater leak sensitivity than that test specified above, such as a helium leak detector, may be used provided prior approval for use of the test method has been obtained from the procuring agency.

4.4.2.8 Dielectric Strength.- There shall be no breakdown of insulation of any of the equipment when it is subjected for 1 minute to a test voltage of 500V rms ac at a commercial frequency applied between any pair of points desired by the testing agency. If the design of the gage is such that there exists between the test points a number of electrical circuit elements which form a conducting path for alternating current which would be damaged by the test voltage, these elements shall be removed prior to application of the test voltage. Where hermetically sealed enclosures are employed, the above test shall be conducted prior to sealing the enclosures. After the enclosures are sealed and pressurized with helium, the same test shall be repeated with the exception that the voltage shall be reduced to 200V.

4.4.3 Sampling Tests.- One gage system and one of each component, as applicable, shall be selected at random from each lot of 100 or fraction thereof and subjected to the following tests. A lot shall consist of identical gages or components with the same manufacturer's part number manufactured under essentially the same conditions and submitted for inspection at substantially the same time.

4.4.3.1 Complete Gage Scale Error at Room Temperature.- The complete gage system shall be electrically connected and the tank unit(s) shall be installed in a suitable test chamber. The gage shall be set to read "zero" with the dry tank unit(s). Master test instruments shall then be connected in parallel with the tank unit(s) and set to the added capacitance values specified for complete immersion in nominal fuel, and the gage shall be set to read "nominal full." The master test instruments shall be removed and nominal fuel shall be poured into the test chamber to the levels specified in table I or table III, as applicable, and the indicator readings shall be noted. The difference between the observed readings and the readings specified shall not exceed 2.0 percent of full scale indication.

4.4.3.1.1 In lieu of nominal fuel, any suitable fuel may be used whose dielectric constant has a known value between 1.90 and 2.05. If the dielectric constant differs from the nominal value of 1.990, the observed indicator readings shall be multiplied by the correction factor listed in table V corresponding to the actual dielectric constant of the fuel.

TABLE V

Correction Factors for Complete Gage Scale Error at Room Temperature Test

| Dielectric Constant | Correction Factor |
|---|---|
| 1.90 | 0.9091 |
| 1.91 | .9192 |
| 1.92 | .9293 |
| 1.93 | .9394 |
| 1.94 | .9495 |
| 1.95 | 0.9596 |
| 1.96 | .9697 |
| 1.97 | .9798 |
| 1.98 | .9899 |
| 1.99 | 1.0000 |
| 2.00 | 1.0101 |
| 2.01 | 1.0202 |
| 2.02 | 1.0303 |
| 2.03 | 1.0404 |
| 2.04 | 1.0505 |
| 2.05 | 1.0606 |

4.4.3.2 Indicator and Intermediate Device Scale Error at Room Temperature.- The indicator and intermediate device shall be assembled and connected to a master test instrument in lieu of the tank unit(s). The master test instrument shall be set to the specified capacitance values corresponding to empty tank and complete immersion in nominal fuel, and the gage shall be adjusted to read "zero" and "nominal full." Once set, the adjustments shall not be altered during the remainder of the tests. The master test instrument shall then be set to the capacitance values specified in table III. The observed readings shall be recorded. Scale errors shall not exceed 0.75 percent of full scale indication at any of the test points. When the gage is designed to provide an output signal for totalizing purposes, the output voltage and/or resistance shall be recorded for each test point. The values established shall not differ from the specified values by more than 0.75 percent. The dead spot of the gage shall be determined and shall not exceed 0.2 percent of total input capacitance range at any two points selected by the Inspector.

4.4.3.2.1 Indicator and Intermediate Device associated with the totalizer shall be tested by means of a precision resistance decade and/or voltage source, as applicable. the observed readings shall be recorded. Scale errors shall not exceed 0.75 percent of full scale indication at any test point, and the dead spot shall not exceed 0.2 percent of total input range.

4.4.3.2.2 Reference Values.- The observed readings in paragraphs 4.4.3.2 and 4.4.3.2.1 will be referred to hereinafter as the "reference values."

4.4.3.3 Tank Unit Assembly Dry Capacitance.- The dry capacitance of the assembled tank units providing a single indication shall be measured at room temperature with the master capacitance bridge. The value obtained shall agree with the specified value within 1.0 percent.

4.4.3.3.1 Reference Value.- The observed reading in paragraph 4.4.3.3 will be referred to hereinafter as "reference value."

4.4.3.4 Voltage and Frequency Variation.- The completely assembled gage shall be tested at three different positions of the indicator pointer, approximately "zero point," midscale, and the scale end, under the following combinations of frequency and voltage of the nominal 115V 400-cps a-c external power source.

| | Voltage | Frequency |
|---|---|---|
| (a) | 115 ±1.0 Volts | 400 ±5 cps |
| (b) | 105 ±1.0 Volts | 360 ±5 cps |
| (c) | 125 ±1.0 Volts | 440 ±5 cps |

The change in indication under conditions (b) and (c) from that observed under condition (a) shall not exceed 0.5 percent of full scale indication. The dead spot of the gage shall be determined at midscale indication under conditions (b) and (c) and shall not exceed 0.2 percent of total input capacitance range.

4.4.3.5 Indicator and Intermediate Device Scale Error at Low Temperature.- The indicator and intermediate device shall be placed in a temperature chamber and subjected to a temperature of -55° ±2°C for a minimum period of 4 hours. The master test instrument shall be maintained at room temperature. At the end of this period while the units are still at the low temperature, scale readings shall be determined by means of the master test instrument. The scale readings shall not differ from the "reference values" by more than 0.75 percent of full scale indication. This test and other tests hereinafter specified covering the same equipment shall apply to indicators and intermediate devices associated with gages (with and without the totalizing feature) and totalizers.

4.4.3.5.1 When the units have returned to room temperature, scale readings shall again be determined by means of the master test unit. The scale readings shall not differ from the "reference values" by more than 0.5 percent of full scale indication.

4.4.3.6 Tank Unit Low Temperature.- The tank unit assembly shall be placed in a temperature chamber and subjected to a temperature of -55° ±2°C for a minimum period of 4 hours. At the end of this period and while the tank unit assembly is still at this temperature, the dry capacitance shall be determined and shall not differ from the respective "reference capacitance" by more than 1.0 percent.

4.4.3.6.1 When the assembly has returned to room temperature, the dry capacitance shall again be determined and shall not differ from the "reference capacitance" by more than 0.5 percent.

4.4.3.7 Indicator and Intermediate Device Scale Error at High Temperature.- The indicator and intermediate device shall be placed in a temperature chamber and subjected to a temperature of 70° ±2°C for a minimum period of 4 hours. The master test instrument shall be maintained at room temperature. At the end of this period and while the units are still at the high temperature, scale readings shall be determined by means of the master test instrument. The scale readings shall not differ from the "reference values" by more than 0.75 percent of full scale indication.

4.4.3.7.1 After the units have returned to room temperature, scale readings shall again be determined by means of the master test instrument. The scale readings shall not differ from the "reference values" by more than 0.5 percent of full scale indication.

4.4.3.8 Tank Unit High Temperature.- The tank unit assembly shall be placed in a temperature chamber and subjected to a temperature of 70° ±2°C for a minimum period of 4 hours. At the end of this period and while the tank unit assembly is still at this temperature, the dry capacitance shall be determined and shall not differ from the "reference capacitance" by more than 1.0 percent.

4.4.3.8.1 When the assembly has returned to room temperature, the dry capacitance shall again be determined and shall not differ from the "reference capacitance" by more than 0.5 percent.

4.4.3.9 Vibration Error.- The Vibration Error test shall be conducted on the components of the gage as specified below.

4.4.3.9.1 Indicator Vibration Resonance.- The indicator and intermediate device shall be electrically connected to each other and to a master test instrument. The indicator shall be subjected to vibration with a circle diameter of 0.009 to 0.011 inch in a plane inclined 45 degrees to the horizontal plane at frequencies of from 300 to 3,000 cpm. The frequency of applied vibration shall be varied slowly throughout the range specified. The maximum double amplitude of the pointer oscillation shall not exceed 0.5 percent of full scale indication, and the pointer variation from its original position shall not be greater than 0.5 percent of full scale indication. The test shall be conducted at an indicator reading of zero and at a minimum of two additional points as selected by the Inspector.

4.4.3.9.2 Indicator Vibration Failure.- The indicator shall be electrically connected as specified in the Indicator Vibration Resonance test. The indicator shall be electrically energized and then adjusted to read approximately "midscale" by means of the master test instrument. The indicator shall be subjected to vibration with a circle diameter of 0.018 to 0.020 inch in a plane inclined 45 degrees to the horizontal plane, and the frequency of vibration shall be varied uniformly from 300 to 3,000 cpm and return once each hour for a 3-hour period. Following the 3-hour period, a scale reading shall be established by means of the master test instrument and shall not differ from the "reference values" by more than 0.5 percent of full scale indication. The indicator shall be inspected thoroughly for damage or defects resulting from the Vibration test.

4.4.3.9.3 Vibration Isolation Suitability - Intermediate Device.- The intermediate device and the associated shock mount shall be vibrated at ambient room temperature in each of three mutually perpendicular directions over a frequency range of 300 to 3,300 cycles per minute at an amplitude of 0.018 inch (0.036-inch total excursion). The frequency shall be varied slowly in each direction over the entire frequency range to determine the resonant frequencies. The amplitude of the intermediate device shall be measured at the point of maximum amplitude in each direction while the frequency is varied from 1,560 to 3,300 cycles per minute. The resonant frequencies shall be 900 cycles per minute or less, and efficiency of the shock mount shall be at least 65 percent at frequencies above 1,560 cycles per minute.

4.4.3.9.4 Intermediate Device and Tank Unit Assembly Vibration.- The intermediate device and tank unit assembly shall be subjected to the frequency range at vibratory accelerations or double amplitudes not exceeding those shown below:

| Frequency in Cycles per Minute | Amplitude |
|---|---|
| 300 - 600 | 0.050 inch |
| 600 - 4,500 | 0.036 inch |
| 4,500 - 30,000 | 10g |

4.4.3.9.4.1 Intermediate Device Vibration Resonance.- The indicator and intermediate device shall be electrically connected to each other and to the master test instrument. The intermediate device shall be mounted on the vibration test stand, and the indicator shall be adjusted to read approximately mid-scale by means of the master test instrument. The intermediate device shall be subjected to vibration. The resonant frequencies of the intermediate device shall be determined by varying the frequency of applied vibration slowly through the range of frequencies at vibratory accelerations not exceeding those specified. The test specimen shall be vibrated at the indicated resonant conditions for 1 hour (time specified refers to one axis of vibration) and with the applied double amplitude or vibratory accelerations specified in paragraph 4.4.3.9.4. These periods of vibration shall be accomplished in sequence for each of three mutually perpendicular axes of vibration. When more than one resonant frequency is encountered with vibration applied along any one axis, the test period shall be conducted at the most severe resonance frequency. When resonant frequencies are not apparent within the specified frequency range, the specimen shall be vibrated twice as long as those specified for resonance at the frequency of 3,300 cpm and an applied double amplitude of 0.060 inch. While the vibration is being conducted, the maximum double amplitude of the indicator pointer oscillation and the pointer variation from its original position shall be noted to determine that they do not exceed 0.5 percent of full scale indication. At the end of the test period, the intermediate device shall be inspected thoroughly to determine that no damage or defects have resulted due to the test.

4.4.3.9.4.2 Intermediate Device Vibration Cycling.- The intermediate device shall be mounted and connected as indicated in paragraph 4.4.3.9.4.1. The intermediate device shall be vibrated with the frequency cycling between 600 and 30,000 cpm in 15-minute cycles at an applied double amplitude of 0.036 inch or an applied acceleration of ±10g, whichever is the limiting value. The vibration shall be conducted 1 hour in each direction along three mutually perpendicular axes. After the Vibration test, a Scale Error test shall be conducted, and the readings established shall not differ from the readings established prior to the test by more than 0.5 percent of full scale at any of the test points. The test specimen shall be thoroughly examined, and no damage shall be noted as a result of the test.

4.4.3.9.4.3 Tank Unit Resonance.- All parts of the gage shall be electrically connected to each other and to the master test instrument. The gage shall be adjusted to read approximately "mid-scale" by means of the master test instrument. The tank units shall be mounted with the flange (for flange-mounted units) fixed to the vibration stand and with end supports and center supports substantially in accordance with types being provided in the respective airplane application. The internally mounted tank units shall also be mounted on the test stand in a manner similar to that being followed in the respective airplane installation. The resonant frequencies of the tank unit or units shall be determined by varying the frequency of applied vibration slowly through the range of frequencies at vibratory accelerations not exceeding those specified. This procedure shall be followed successively for vibration applied along three mutually perpendicular axes of the test specimen. The test specimen shall be vibrated at the indicated resonant conditions for 1 hour (time specified refers to one axis of vibration) and with the applied double amplitude or vibratory acceleration specified in paragraph 4.4.3.9.4. These periods of vibration shall be accomplished in sequence for each of three mutually perpendicular axes of vibration. When more than one resonant frequency is encountered with vibration applied along any one axis, the test period shall be accomplished at the most severe resonance frequency. When resonant frequencies are not apparent within the specified frequency range, the specimen shall be vibrated twice as long as those specified for resonance at a frequency of 3,300 cpm and an applied double amplitude of 0.060 inch. While the vibration is being conducted, the maximum double amplitude of the indicator pointer oscillation and the pointer variation from its original setting shall be noted to determine that they do not exceed 0.5 percent of full scale indication. The dry capacitance shall be determined after the test and shall not differ from respective reference capacitance by more than 0.5 percent. The tank unit or units shall be thoroughly inspected to determine that no damage has occurred as a result of the test.

4.4.3.9.4.4 Tank Unit Cycling.- The tank unit assembly shall be mounted as specified in paragraph 4.4.3.9.4.3, but shall not be electrically connected to the remaining parts of the gage. The tank units comprising the assembly shall be electrically connected to each other and vibrated with a constant applied vibratory acceleration of ±10g with the frequency cycling between 600 and 30,000 cpm in 15-minute cycles at an applied double amplitude of 0.036 inch or an applied acceleration of ±10g, whichever is the limiting value. The vibration shall be conducted 1 hour in each direction along three mutually perpendicular axes. After the Vibration test, the dry capacitance of the tank unit assembly shall be again measured and shall not differ from the reference capacitance by more than 0.5 percent. The tank unit assembly shall be inspected to determine that no damage has resulted because of the test.

4.4.3.9.4.5 In the event that vibration testing equipment is not available to perform the Cycling test as specified in paragraphs 4.4.3.9.4.2 and 4.4.3.9.4.4, the cycling shall be accomplished only at frequencies ranging from 600 to 3,300 cpm and at an applied double amplitude of 0.036 inch. The frequency of vibration shall be varied uniformly from 600 to 3,300 cpm and return once each hour. The time of the vibration shall be 1 hour in each direction along three mutually perpendicular axes.

4.4.4 Special Tests.- Two gage systems and two of each components, as specified in the following tests, shall be selected from the first 15 gage systems or components of each type produced and shall be subjected to the following tests. The Cycling test will be omitted on one gage system, and the Humidity and Fungus tests will be omitted on the other gage system.

4.4.4.1 Vacuum Tube Replacement.- The indicator and intermediate device shall be electrically connected to each other and to a suitable master variable capacitor. The master capacitor shall be adjusted to a value such that the indicator reads approximately one-quarter full, or to any other points as desired by the qualifying agency, or Inspector, as applicable. Each vacuum tube employed in the gage system shall be removed individually and replaced consecutively with six tubes of the same type designation taken at random from stock. The difference in reading obtained with the original tube and any of the stock replacement tubes shall not exceed 0.3 percent of full scale indication.

4.4.4.2 Speed of Response.- For nonsensitive indicators, the pointer shall travel from zero to end-point or vice versa within a period of 1 minute at room temperature, and for sensitive indicators of the sub-dial type the pointer travel period for the main pointer shall be within 2 minutes. After the indicator has been maintained at -55° ±2°C for a minimum period of 2 hours, the time required for the pointer to travel over the design range shall not exceed the time specified for the Room Temperature test by more than three times.

4.4.4.3 Radio Noise Suppression.- Radio noise suppression shall be in accordance with Specification MIL-I-6181, except that a frequency range of from 0.15 to 150 megacycles shall apply for the Radiated Radio Noise test.

4.4.4.4 Indicator Magnetic Effect.- The indicator, not operating, shall be rotated in a vertical plane about a short bar magnet compass with the nearest part of the indicator 5-1/2 inches 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 on its own horizontal axis until it is in its normal upright position. The horizontal magnetic field intensity shall be 0.17 to 0.19 gauss. The deflection of the compass at any of the specified positions shall not exceed 5 degrees. The test shall be repeated with the indicator operating at rated voltage.

4.4.4.5 Extreme Low Temperature Exposure.-

4.4.4.5.1 Indicator and Intermediate Device Scale Error.- These units shall be tested as specified in paragraph 4.4.3.5, except that the units shall be maintained at a temperature of -65° ±2°C for a period of 48 hours, and the temperature raised to -55° ±2°C for a period of 24 hours. During the last 4 hours of the 24-hour period at -55°C, the pressure shall be reduced to 0.82 inch Hg absolute, or less. At the completion of the 24-hour period while at the temperature and pressure specified above, the units shall be tested to determine that the scale readings shall not differ from the "reference values" by more than 1.0 percent of full scale indication.

4.4.4.5.1.1 When the units have returned to room temperature, scale readings shall again be determined by means of the master test instrument. The scale readings shall not differ from the "reference values" by more than 0.5 percent of full scale indication.

4.4.4.5.2 Tank Unit.- The tank unit assembly shall be tested as described in paragraph 4.4.3.8, except that the assembly shall be maintained at a temperature of -65° ±2°C for a period of 48 hours, and the temperature then raised to -55° ±2°C for a period of 24 hours. During the last 4 hours of the 24-hour period at -55°C, the pressure shall be reduced to 0.82 inch Hg absolute, or less. At the completion of the 24-hour period while at the temperature and pressure specified above, the dry capacitance shall be measured and shall not differ from the "reference capacitance" by more than 1.0 percent.

4.4.4.5.2.1 When the assembly has returned to room temperature, the dry capacitance shall again be determined and shall not differ from the "reference capacitance" by more than 0.5 percent.

4.4.4.6 High Temperature Exposure.-

4.4.4.6.1 Indicator and Intermediate Device Scale Error.- These units shall be tested as described in the Intermediate Device Scale Error at High Temperature test, except that the units shall be maintained at a temperature of 70° ±2°C for a period of 24 hours. While still at this temperature, the scale readings shall not differ from the "reference values" by more than 1.0 percent of full scale indication.

4.4.4.6.1.1 When the units have returned to room temperature, scale readings shall again be determined by means of the master variable capacitor. The scale readings shall not differ from the "reference values" by more than 0.5 percent of full scale indication.

4.4.4.6.2 Tank Unit.- The tank unit assembly shall be tested as described in the Tank Unit High Temperature test, except that the assembly shall be maintained at a temperature of 70° ±2°C for a period of 24 hours. While still at this temperature, the capacitance shall not differ from the "reference capacitance" by more than 1.0 percent.

4.4.4.6.2.1 When the assembly has returned to room temperature, the dry capacitance shall again be determined and shall not differ from the "reference capacitance" by more than 0.5 percent, respectively.

4.4.4.7 Tank Unit Immersion.- The tank unit assembly of the gage shall be mounted in a suitable tank. The tank shall then be filled to approximately three quarters of its capacity with fuel conforming to Specification MIL-F-5572. After the gage reading and the fuel level have been noted, approximately one half of the remaining space in the tank shall be filled with distilled water, and the tank shall then be sealed. The tank shall then be inverted for 1 minute and restored to its normal upright position for 5 minutes. This procedure shall be repeated four times. The water shall be drained from the tank and, if necessary, fuel shall be added to restore the original fuel level. The gage reading shall be noted, and the change of indication from the original reading shall not exceed 2 percent of the nominal full scale indication.

4.4.4.8 Humidity.- All parts of the gage shall be mounted in their normal operating position in a suitable chamber and the temperature and relative humidity raised to 70° ±2°C (158° ±3.6°F) and 95 ±5 percent, respectively, during a 2-hour period. The temperature of 70°C and relative humidity of 95 percent shall be maintained for a period of 6 hours. At the conclusion of the 6-hour period the heat shall be shut off. During the following 16-hour period the temperature will be allowed to drop with condensation to 38°C (100°F) or below. This cycle shall be repeated a sufficient number of times to extend the total time of test to 360 hours (15 cycles). At the end of the 360-hour period, the following tests shall be conducted.

4.4.4.8.1 Indicator and Intermediate Device Scale Error.- Within 1 hour after exposure to humidity, scale errors shall be determined by means of the master test instrument. The scale readings shall not differ from the "reference values" by more than 2.0 percent of full scale indication.

4.4.4.8.1.1 Between 24 and 48 hours after exposure to humidity, scale readings shall again be determined by means of the master test instrument. The scale readings shall not differ from the "reference values" by more than 1.0 percent of full scale indication. There shall be no evidence of corrosion or other deterioration which will affect subsequent operation of the gage.

4.4.4.8.2 Tank Unit.- Within 1 hour after exposure to humidity, the dry capacitance shall be determined and shall not differ from the "reference capacitance" by more than 2.0 percent.

4.4.4.8.2.1 Between 24 and 48 hours after exposure to humidity, the dry capacitance shall again be determined and shall not differ from the "reference capacitance" by more than 1.0 percent. There shall be no evidence of corrosion or other deterioration which will affect subsequent operation of the gage.

4.4.4.8.3 This test is not applicable to completely hermetically sealed components.

4.4.4.9 Fungus Resistance.- The gage and its component parts shall be placed in a mould chamber and shall be sprayed with a suspension of mixed spores similar to those encountered in tropical climates. At least five fungi shall be used in each test. Five groups of fungi are listed below and one type of fungus from each group shall be used.

| | |
|---|---|
| Group I | Chaetomium globosum USDA 1042.4 or Myrothecium verrucaria USDA 1334.2. |
| Group II | Rhizopus nigricans S. N. 32 or Aspergillus niger USDA - Tc215-4247. |
| Group III | Aspergillus flavus AMC No. 26 or Aspergillus terreus PQMD82j. |
| Group IV | Penicillium luteum USDA 1336.1, Penicillium sp. USDA 1336.2 or Penicillium citrinum ATCC 9848. |
| Group V | Memnoniella echinata AMC No. 37 or Fusarium moniliforme USDA 1004.1. |

Substitutions for the above fungi may be made provided they are acceptable to the agency performing Qualification tests. At the option of the procuring agency, tests on component parts of the gage may be accepted in lieu of or in addition to tests on the assembled gage. The temperature of the chamber shall be maintained at 30° ±2°C (86° ±3.6°F) with a relative humidity of 95 ±5 percent. The duration of this test shall be 14 days. At the end of the test period, the equipment shall be carefully examined to ascertain that no fungus growth has occurred. This test is not applicable to completely hermetically sealed components.

4.4.4.10 Salt Spray.- All parts of the gage which are outside of the fuel cell shall be subjected to Salt Spray tests in accordance with Specification QQ-M-151 for a period of 50 hours. Upon completion of the test, the components shall be subjected to the following tests.

4.4.4.10.1 Indicator and Intermediate Device Scale Error.- Scale readings shall be determined by means of the master test instrument. The scale readings shall not differ from the "reference values" by more than 2.0 percent of full scale indication. There shall be no evidence of corrosion or other deterioration which will affect subsequent operation of the gage.

4.4.4.10.2 Tank Unit.- The dry capacitance shall be determined and shall not differ from the "reference capacitance" by more than 2.0 percent. There shall be no evidence of corrosion or other deterioration which will affect subsequent operation of the gage.

4.4.4.11 Cycling Test, Indicator and Intermediate Device.- The indicator and associated intermediate device shall be electrically connected to the master test instrument (variable capacitor simulating the tank unit assembly). During the cycling procedure the capacitance shall be continuously varied in order that the indicator pointer moves from "zero" to "end" point and return to "zero" within 5 minutes ±1 minute. The total cycling period shall be a minimum of 5,000 cycles and shall be conducted in 12-cycle intervals. After each interval the gage shall be deenergized electrically a minimum of 10 minutes between cycling intervals. After the Cycling test, a Scale Error test shall be conducted, and the readings established shall not differ from those established prior to the test by more than 0.50 percent of full scale at any test point. The test shall be applicable to all indicators and intermediate devices identified by the manufacturer by different basic part numbers.

4.4.4.12 Thermal Shock.- Hermetically sealed component parts of the gage as defined in paragraph 4.4.2.7 shall be alternately subjected to a total of eight cycles of immersion in tap water maintained at 85° ±5°C and 5° ±5°C. The length of the time for each bath immersion shall be 30 minutes; not more than 5 seconds shall elapse between bath immersions. No evidence of moisture penetration or damage to the inclosure shall result from this test. Following this test, the test specimen shall be resubjected to the Sealing test.

4.4.4.13 Case Mounting Lugs.- This test is applicable only to indicators conforming to figure 1. The indicator case, with mechanism removed, shall be mounted face downward on the movable head of a suitable testing machine with the face of the case in a horizontal plane, in order that the mounting lugs receive no added support. A suitable pin shall be inserted through the hole in the mounting lug and attached to a pull strap in the stationary head of the machine. A load of 175 pounds shall be applied for 1 minute to each lug in a direction toward the front of the case. The lugs shall withstand the applied load without fracture.

4.4.5 Rejection and Retest.- When tests are specified on a quantity of gages that are selected as representative of a certain lot, and one or more of this number fails to meet the specified tests, additional gages of the lot represented shall be tested immediately to determine the cause of failure. Individual performance tests shall not be interrupted, unless the defect is of such a nature that it will seriously affect the performance or safe use of the gage.

4.4.5.1 Items which have been rejected may be reworked or replaced to correct the defects and resubmitted for acceptance. Before resubmitting, full particulars concerning previous rejection and the action taken to correct the defects found in the original shall be furnished the Inspector. Units rejected after retest shall not be resubmitted without specific approval of the procuring agency.

## 5. PREPARATION FOR DELIVERY

5.1 Application.- The requirements specified herein apply only to direct purchases by or direct shipments to the Government.

5.2 Packaging and Packing.- The Indicator and Intermediate Device shall be packaged and packed for shipment in accordance with group X of Specification MIL-P-6064, in a type II, class I container.

5.2.1 Items too large for shipment in a container as described in Specification MIL-P-6064 shall be packaged in accordance with Specification MIL-P-5633.

5.2.2 Tank Units.- Each tank unit shall be preserved and packaged in accordance with Specification AN-P-13, method II.

5.3 Marking and Labeling.- Marking shall be in accordance with the requirements of Specification MIL-P-6064 and as specified herein.

5.3.1 Packages.- Each package shall be durably and legibly marked with the following information:

Indicator (Or Tank Unit, Power Unit, Amplifier, etc., as applicable) for
GAGE, FUEL QUANTITY CAPACITOR TYPE
Specification MIL-G-7817
Manufacturer's Part No.
Manufacturer's Serial No.
Stock No. (USAF or Navy, as applicable)
Contract or Order No.
Quantity
Date of Manufacture
Name of Manufacturer
Name of Contractor (if different from the manufacturer)

IF IN STORAGE AFTER (DATE)*, THE GAGE SHALL BE TESTED AND INSPECTED BEFORE USE.

*NOTE: This date shall be 3 years from the date of inspection and shall be inserted by the Inspector at the time of acceptance.

5.3.2 Precautionary Markings.- The following precautionary marking shall appear on two opposite sides of each interior package, whenever practicable, depending on the size of the carton and shall also appear on the shipping container:

"FRAGILE
DELICATE INSTRUMENTS
HANDLE WITH CARE"

## 6. NOTES

6.1 Intended Use.- The fuel quantity gages covered by this specification are intended for use in reciprocating engine aircraft to indicate the quantity of fuel (in pounds) contained in fuel tanks.

6.2 Definitions.-

6.2.1 Amplitude.- The term "amplitude" as used herein shall be interpreted to mean the distance from the mean position to either extreme. "Double Amplitude" is two times the "amplitude."

6.2.2 Zero Point.- "Zero Point" is defined as the beginning of the dial graduations, which represents an indication of zero fuel quantity (dry tank unit).

6.2.3 Full Scale Indication.- "Full Scale Indication" is defined as the indication corresponding to a full tank of fuel having a density of 6.593 lb/gal.

6.2.4 Procuring Agency.- In this specification, the term "procuring agency" refers to the U. S. Air Force or Bureau of Aeronautics, U. S. Navy.

6.2.5 Density.- The density values used in this specification are relative values, defined as the ratio of the apparent mass of fuel to the true volume. The apparent mass is the value obtained by weighing the fuel in air at 15.6°C (60°F), 50-percent relative humidity and 760 mm of mercury pressure against brass weights of specific gravity 8.4, no corrections being applied for air buoyancy. The true density of aircraft fuels is about 0.009 lb/gal larger than the apparent density.

6.2.6 Nominal Full Indication.- Nominal Full indication is defined as the indication corresponding to full tank of nominal fuel of density 6.00 lb/gal and dielectric constant of 1.990. It is equal to 91 percent of full scale indication.

6.3 Provisions for Qualification Tests.- The right is reserved to reject any bids on items which have not been subjected to the required tests and found satisfactory. The attention of the manufacturers is called to this provision, and they are urged to request authorization for tests of the items which they propose to offer to the Air Force or Navy under this specification. Requests for authorization of tests, together with certified test reports showing conformance with all the requirements of this specification and the manufacturer's assembly and detail drawings, and for information as to the marking and forwarding of samples should be addressed to the Commanding General, Wright Air Development Center, Wright-Patterson Air Force Base, Dayton, Ohio; or to the Bureau of Aeronautics, Navy Department, Washington 25, D. C., the qualifying agencies, with a copy to the other Service.

6.3.1 It is to be understood that upon receipt of the Letter of Authorization, samples shall be furnished at no cost to the Government, and that the manufacturer shall pay the transportation charges to and from the designated point where tests are to be made. In the case of failure of the sample or samples submitted, consideration will be given to the request of the manufacturer for additional tests only after it has been clearly shown that changes have been made in the product which the Government considers sufficient to warrant additional tests.



Custodians:
Navy - Bureau of Aeronautics
Air Force