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MIL-E-23919A(SH)
18 April 1983
SUPERSEDING
MIL-E-23919(SHIPS)
29 November 1963
(See 6.5)

MILITARY SPECIFICATION

ELECTRODES, REFERENCE, CIRCULAR, CORROSION PREVENTIVE, (FLUSH TYPE): SILVER-SILVER CHLORIDE

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

1. SCOPE

1.1 Scope. This specification covers the requirements for circular silver-silver chloride flush type reference electrode used in impressed current cathodic protection systems. The reference electrode provides the control signal to the impressed current system and may be used to monitor the system operation. It includes features of design and fabrication of these electrodes, including alternate components.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

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

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 55Z3, Department of the Navy, Washington, DC 20362 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FSC 2040

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SPECIFICATIONS

FEDERAL

NN-P-71	- Pallets, Material Handling, Wood, Stringer Construction, 2-Way and 4-Way (Partial).
QQ-S-365	- Silver Plating, Electrodeposited: General Requirements for.
QQ-S-763	- Steel Bars, Wires, Shapes, and Forgings, Corrosion-Resisting.
PPP-B-601	- Boxes, Wood, Cleated-Plywood.
PPP-B-621	- Boxes, Wood, Nailed and Lock-Corner.
PPP-B-636	- Boxes, Shipping, Fiberboard.

MILITARY

MIL-P-116	- Preservation, Methods of.
MIL-P-3410	- Plastic-Material, Molding; Rigid Thermoplastic, Polyvinyl Chloride and Copolymers Thereof; For Use in Electronic, Communications, and Allied Electrical Equipment.
MIL-S-8660	- Silicone Compound.
MIL-P-15011	- Pallets, Material Handling, Wood Post Construction, 4-way Entry.
MIL-B-22191	- Barrier Materials, Transparent, Flexible, Heat-Sealable.
MIL-P-25732	- Packing, Preformed, Petroleum Hydraulic Fluid Resistant, Limited Service at 275°F (135°C).

STANDARDS

FEDERAL

FED-STD-H28/2	- Unified Thread Form and Thread Series for Bolts, Screws, Nuts, Tapped Holes and General Application.

MILITARY

MIL-STD-129	- Marking for Shipment and Storage.
MIL-STD-1186	- Cushioning, Anchoring, Bracing, Blocking and Waterproofing; with Appropriate Test Methods.

AIR FORCE-NAVY AERONAUTICAL

AN6227	- Packing, O-Ring Hydraulic.

(Copies of specifications and standards required by contractors in connection with specific acquisition functions should be obtained from the contracting 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. The issues of the documents which are indicated as DoD adopted shall be the issue listed in the current DoDISS and the supplement thereto, if applicable.

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AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)
B 139 - Specification for Phospher Bronze Rod, Bar and Shapes. (DoD adopted)

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

UNIFORM CLASSIFICATION COMMITTEE AGENT
Uniform Freight Classification Ratings, Rules and Regulations

(Application for copies should be addressed to the Uniform Classification Committee Agent, Tariff Publication Officer, Room 1106, 222 South Riverside Plaza, Chicago, IL 60606.)

(Industry association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

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

3. REQUIREMENTS

3.1 Description.

3.1.1 Physical. The reference electrode shall consist of an electrode element of treated silver gauze wrapped in a copolymer (see 3.3.5) screen and encased in a circular plastic holder and plastic base. A silver wire shall connect the electrode element to a silver-plated phosphor-bronze pin which shall extend out from the center of a hub in the base and shall be the means by which the electrode is connected to other components of the cathodic protection system, (see figure 1).

3.1.2 Electrical. The reference electrode shall be accurate to plus or minus 0.010 volt relative to a standard reference saturated calomel electrode which can be traced to the U.S. Bureau of Standards standard reference (see 4.2.4).

3.2 Materials.

3.2.1 Reference electrode.

3.2.1.1 Silver-silver chloride electrode element. The silver-silver chloride electrode element shall be 16 ± 1/32 inch by 4 ± 1/32 inch piece of silver chloride treated silver gauze, woven of silver wire 10 ± 1.5 mils in diameter to a no. 40 mesh. The silver wire used in fabricating the gauze shall contain not less than 99.95 percent pure silver. The gauze shall be wrapped in a 1-inch wide fine copolymer wire (see 3.3.5) screen woven of copolymer wire (copolymer of vinylidene chloride and vinyl chloride) 15 ± 1.5 mils in diameter, and shall be enclosed in a pouch-type bag made of copolymer screen woven of copolymer wire, with a drawstring of copolymer wire 14 inches ± 1 inch long.

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3.2.1.2 Plastic holder and base. The plastic holder and base shall be machined polyvinyl chloride conforming to MIL-P-3410. The hub, if fabricated separately, shall be the same material cemented to the base plate with vinyl adhesive. The adhesive shall be Bakelite UMCH 20 percent by weight in tetrahydrofuran, or equivalent.

3.2.1.3 Silver wire. The silver wire connecting the electrode element to the projecting pin shall contain not less than 99.95 percent pure silver.

3.2.1.4 Pin. The pin projecting from the electrode shall be silver-plated phosphor-bronze. The silver plating shall be deposited on the pin and the silver wire extending from the pin in accordance with the requirements of type I, grade A of QQ-S-365, to a thickness of 0.0005 inches. The quality assurance tests for solderability (soft solder) and surface roughness are not required. The phosphor-bronze shall be an alloy conforming to the composition specified in ASTM B 139, alloy B2.

3.2.1.5 O-rings. O-rings for the hub of the base assembly shall be circular rubber rings conforming to MIL-P-25732. Size and shape shall be AN 6227-13 as specified in AN6227. Sealing grease for installation of the O-rings shall conform to MIL-S-8660.

3.2.1.6 Screws and washers. The screws for fastening together the plastic holder and base assembly shall be nylon screws of the flat head type. The screws and washers used to attach the holder and base to the structure to be protected shall be corrosion-resistant steel conforming to class 316/316L, condition A of QQ-S-763.

3.3 Manufacture.

3.3.1 Silver-silver chloride electrode element. The silver gauze shall be folded with an accordion pleat to form a 4 ± 1/32-inch square. A silver wire (3/32 ± 1/64 inch diameter) shall be swaged in the center of the first edge of the gauze using no solder or flux, (see 3.3.4 and figure 1). The element shall then be treated as follows before insertion in the plastic holder. The gauze shall be handled with a stainless steel tong to prevent contamination. The gauze shall be cleaned by holding the gauze in a reducing flame of a hydrogen gas burner for at least 30 seconds. The silver surface should be bright and shiny when removed from the flame. The gauze shall be immediately dipped into molten chemically pure (CP grade - commercial analyzed reagent) silver chloride, maintained at slightly above 455 degrees Celsius (°C), and held for a sufficient amount of time (approximately 30 seconds) for the gauze to reach the temperature of the silver chloride. This shall result in a weight gain of approximately 30 grams. The gauze shall be allowed to cool for approximately 60 seconds, then it shall be returned to the reducing hydrogen flame for 10 to 15 seconds. If the reference potential criteria of 4.2.4 is not met, reheat the gauze in a reducing hydrogen flame for 30 seconds and redip into the molten chemically pure silver chloride for approximately 30 seconds to result in a weight gain of approximately 30 grams.

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3.3.2 Plastic holder and base assembly. The plastic holder and base assembly shall be manufactured by machining polyvinyl chloride plate. The polyvinyl chloride holder and base assembly may also be molded to size and then machined to finish dimensions and tolerances where necessary (see figure 1).

3.3.3 Pin. The phosphor-bronze pin shall be manufactured by machining a phosphor bronze bar. The pin shall be 2-7/8 inches ± 1/32 inch long with a diameter of 0.250 ± 0.005 inch. One end of the pin shall be rounded to a 1/8 ± 1/64 inch spherical diameter. The other end shall be flat. A number 40 hole shall be drilled in the flat end of the pin 1/2 ± 1/32-inch deep along the center axis to accept the silver connecting wire. The exterior of the pin shall be knurled for 7/8 ± 1/32 inch along the length beginning at the flat end.

3.3.4 Silver wire. A 3/32 ± 1/64-inch diameter by 9 ± 1/32 inch long silver wire shall be inserted into the phosphor bronze pin and silver-soldered to the pin prior to silver plating. The pin and wire junction shall be plated as a unit to an average thickness of 0.0005 inch. A second 3/32 ± 1/64-inch diameter silver wire at least 9 inches long shall be fused to the silver gauze prior to treatment, using no solder or flux. This fusing may be performed by tungsten inert-gas arc-welding.

3.3.5 Vinylidene chloride and vinyl chloride copolymer. The element, after it has cooled, shall be trimmed to 4-3/8 ± 1/32-inch diameter (see figure 1), and loosely wrapped in 1-inch wide vinylidene chloride and vinyl chloride copolymer screen strips and enclosed in a pouch type bag made of copolymer screen with a copolymer filament wire draw string (14 ± 1 inch long). The silver wire shall extend from the bag at least 7 inches. The copolymer screen shall be woven of copolymer wire of .015 ± .0015 inch diameter. This package shall be approximately 0.5 inch thick.

3.3.6 Assembly. The pin shall be attached to the hub of the assembly base by cementing with epoxy resin. The end of the silver wire protruding from the pin and base assembly shall be fused to the end of the silver wire attached to the element or by swagging metal to metal. If the hub has been fabricated separately from the base assembly, the two shall be cemented together in accordance with 3.2.1.2. The element shall be placed in the plastic holder and the holder and base assembly shall be attached with flat head nylon screws (see figure 1).

3.4 Mechanical and physical properties.

3.4.1 Dimensions. The reference electrode and its component parts shall conform to the dimensions shown on figure 1. The hub may be integrally-molded or constructed as a separate piece and cemented to the base.

3.4.1.1 Eccentricity of reference electrode. The hub of the plastic base shall be positioned axially and concentrically in relation to the circle of bolt holes in the base. Eccentricity of the hub in relation to the ring of bolt holes shall not be in excess of 0.010 inch.

3.4.1.2 Eccentricity of electrode. The pin shall be placed axially and concentrically in relation to the hub. Eccentricity of the pin in relation to the hub shall not be in excess of 0.0075 inch.

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3.4.1.3 Eccentricity of O-ring grooves. The grooves in the hub of the plastic base shall be smooth and without spiral tool marks. Eccentricity of the grooves in relation to the outer diameter of the hub shall not be in excess of 0.003 inch.

3.4.2 Pressure test. The electrode shall be leak tested with helium gas at 100 $\pm$ 10 pounds per square inch (lb/in^2) for 2 minutes to determine that no leak path exists from the electrode base to the rear of the pin (see 4.2.5).

3.5 Marking of electrodes. The number of this specification and a capital letter indicating the current revision to this specification shall be placed on the outer surface of each plastic holder. In addition, a manufacturer's identifying symbol shall also be molded or engraved on the outer surface of each plastic holder.

3.6 Workmanship.

3.6.1 Plastic holder and base assembly. Each plastic holder and base assembly shall be smooth and free of burns, bubbles, and similar defects consistent with good commercial practice.

3.6.2 Pin. The pin projecting from the hub of the base assembly shall be smooth and straight and free of burns, dents, scratches, cuts, and other defects of similar nature consistent with good commercial practice.

4. QUALITY ASSURANCE PROVISIONS

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

4.2 Production quality conformance inspection and test.

4.2.1 Lot. Unless otherwise specified in the contract or order, a lot shall consist of those electrodes offered for delivery at one time or during a fixed period of time, which have been manufacturered or processed under substantially the same conditions with no change in glass reinforcement or resin formulation.

4.2.2 Sampling for examination and test. From each lot specified in 4.2.1, electrodes shall be selected at random in accordance with table I for tests specified in 4.2.3, 4.2.4, and 4.2.5. The lot shall be accepted if the number of sample defects is less than or equal to the acceptance number for the individual tests.

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4.2.3 Visual examination, dimensional check and workmanship. Each of the electrodes in the sample selected in accordance with table I shall be examined for visual and dimensional characteristics. Workmanship shall be in accordance with 3.6. Dimensions of the holder, base and projecting pin shall be in accordance with figure 1.

TABLE I. Sampling procedure for examination and test.

Lot size	Number of electrodes selected	Number of failures allowed		
		Visaul examination	Comparison test	Pressure test
1 to 15	All	0	0	0
16 to 25	15	1	0	0
26 to 40	20	1	0	0
41 to 65	25	2	0	0
66 to 110	30	2	0	0
111 to 180	35	3	0	0
181 and over	50	4	0	0

4.2.4 Reference comparison test. Electrodes shall be tested against a standard reference saturated calomel electrode which can be traced to the U.S. Bureau of Standards standard reference. Electrodes shall be tested in 25 $\pm$ 1 ohm-cm, 3.5 percent sodium chloride solution at 28°C. Electrodes shall be allowed to stabilize (open circuit) in the sodium chloride solution approximately 15 minutes before testing. The comparison tests shall be made with a voltmeter with an accuracy to plus or minus 0.1 millivolts (mV) and an input impedance of at least 1 megohm. Deviation voltage by the test cell from the standard by more than 10 mV shall be cause for rejection of the lot. The lot rejected may be resubmitted for retest after rework by heating the gauze with a hydrogen torch and redipping in the silver chloride (see 3.3.1).

4.2.5 Pressure test. Each sample electrode shall be mounted in a pressure test fixture, as shown on figure 2. A pressure of 100 $\pm$ 10 lb/in^2 shall be applied to the base, electrode and pin assembly prior to assembly of the holder. The tube inserted over the electrode hub and O-rings shall be filled with "Windex" or a simliar colored translucent liquid containing a wetting agent. The pressure shall be maintained for 2 minutes. No bubbles shall appear.

4.2.6 Electrical continuity test. Each sample electrode shall be tested for electrical continuity with an ohm meter or similar device that will indicate such continuity. One terminal of the device shall contact the end of the pin and the other terminal shall contact the active electrode surface. A steady resistance reading of 1 ohm or less shall indicate continuity.

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4.3 Inspection of packaging. Sample packages and packs, and the inspection of the preservation-packaging, packing and marking for shipment and storage shall be in accordance with the requirements of section 5 and the documents specified therein.

5. PACKAGING

(The preparation for delivery requirements specified herein apply only for direct Government acquisition. For the extent of applicability of the preparation for delivery requirements of referenced documents listed in section 2, see 6.4.)

5.1 Packaging requirements. Packaging shall be level A or C, as specified (see 6.2.1).

5.1.1 Level A. Each electrode shall be placed in a plastic bag fabricated from material conforming to MIL-B-22191, type I. Bag closure may be by heat sealing with enough material that two additional heat seals may be effected for inspection purposes. Alternately the bag closure may be of a recloseable type that will assure the requirements for method IC, MIL-P-116. Each electrode shall be snugly fitted into fiberboard boxes to meet or exceed requirements of type CF, class domestic of PPP-B-636. The reference electrodes shall be immobilized within the boxes with solid fiberboard or other suitable separators. The gross weight of the boxes shall not exceed the weight limitations of the fiber box specifications.

5.1.2 Level C. Preservation and packaging shall be sufficient to afford physical protection against damage during shipment from the supply source to the first receiving activity for immediate use. This level may conform to the contractor's commercial practice when such meets the requirements of this level.

5.2 Packing. Packing shall be level A, B, or C as specified (see 6.2.1).

5.2.1 Level A. Reference electrodes shall be packed in unit pallet loads or in boxes in accordance with the following.

5.2.1.1 Pallets shall conform to NN-P-71 or MIL-P-15011. The reference electrodes shall be secured to the pallet with tension-tied, coated or galvanized, steel strapping applied lengthwise and girthwise. Minimum size of the strapping shall be 3/4 by 0.035 inch. The gross weight of the pallet load shall not exceed 3,000 pounds.

5.2.1.2 The boxes shall conform to PPP-B-601 (overseas type) or class 2 overseas, style 2, grade B of PPP-B-621. The gross weight of the box shall not exceed approximately 500 pounds. Box closure and strapping shall be in accordance with the applicable box specification or appendix thereto. The boxes shall be modified by the addition of skids, for gross weights exceeding 200 pounds, in accordance with the applicable box specification.

5.2.1.3 The reference electrodes shall be cushioned, blocked and braced in accordance with MIL-STD-1186.

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5.2.2 Level B. Reference electrodes shall be packed in unit pallet loads or in boxes in accordance with the following.

5.2.2.1 Pallets shall be as specified in 5.2.1.1.

5.2.2.2 The boxes shall conform to class 2 overseas, style 2, grade B of PPP-B-621, or PPP-B-601 (domestic type). The gross weight of the box shall not exceed approximately 500 pounds. Box closure shall be in accordance with the applicable box specification or appendix thereto. The boxes shall be modified by the addition of skids, for gross weights exceeding 200 pounds, in accordance with the applicable box specification.

5.2.2.3 The reference electrode shall be cushioned, blocked and braced so as to prevent damage during shipment.

5.2.3 Level C. Reference electrode shall be packed in containers, at the lowest rates, in a manner which will insure acceptance by common carrier and will afford protection against physical or mechanical damage during direct shipment from the supply source to the first shipment from the supply source to the first receiving activity for immediate use. This level in general shall conform to the Uniform Freight Classification Rules and Regulations or other carrier regulations as applicable to the mode of transportation and may be the contractor's commercial practice when such meets the requirements of this level.

5.3 Marking. Marking of the packages and shipping containers shall be in accordance with MIL-STD-129.

6. NOTES

6.1 Intended use. The reference electrodes are primarily intended for use in corrosion prevention in sea water of ship hulls, structures, sea chests, sonar domes and similar marine structures. The reference electrodes supply the central signal to the automatic control impressed current cathodic protection system. The electrodes shall be attached to the structure to be protected by means of stuffing tubes in accordance with MIL-S-23920, class B.

6.2 Ordering data.

6.2.1 Acquisition requirements. Acquisition documents should specify the following:

(a) Title, number, and date of this specification.
(b) Level of preservation, packaging and packing required (see 5.1 and 5.2).
(c) Number of reference electrodes per package (see 5.1 and 5.2).

6.3 Noncompliance. If a sample fails to pass any of the production quality conformance inspections and tests in section 4.2, the lot shall be considered rejected. All rejected samples shall be returned to the manufacturer for rework or replacement. Shipping of rejected samples shall occur at no expense to the Government.

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6.4 Sub-contracted material and parts. The preparation for delivery requirements of referenced documents listed in section 2 do not apply when material and parts are acquired by the contractor for incorporation into the equipment and lose their separate identity when the equipment is shipped.

6.5 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue, due to the extensiveness of the changes.

Preparing activity:
Navy - SH
(Project 2040-N151)

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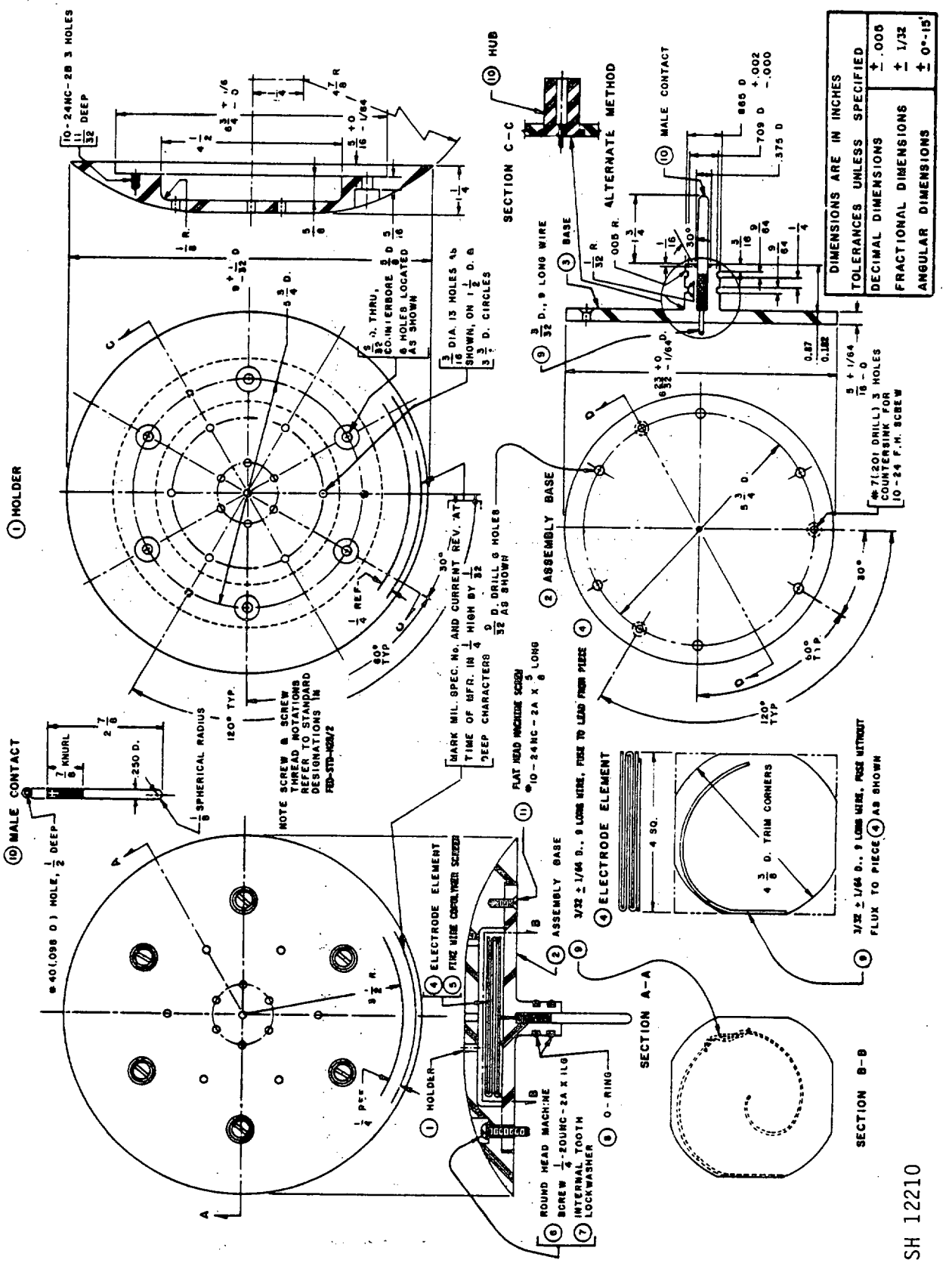

SH 12210

FIGURE 1. Reference electrode-silver-silver chloride.

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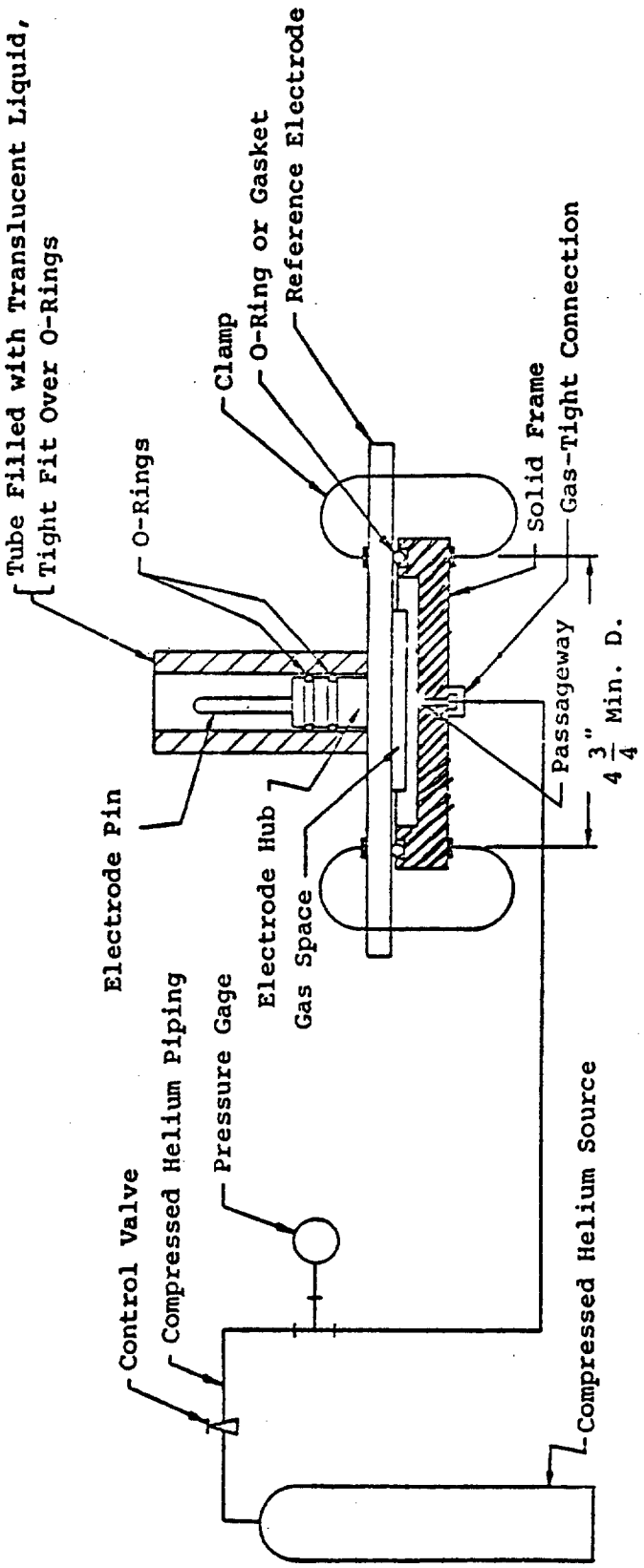

SH 12211

FIGURE 2. Pressure test arrangement.

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STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE
MIL-E-23919A(SH)	

3a. NAME OF SUBMITTING ORGANIZATION	4. TYPE OF ORGANIZATION *(Mark one)*
	☐ VENDOR
b. ADDRESS *(Street, City, State, ZIP Code)*	☐ USER
	☐ MANUFACTURER
	☐ OTHER *(Specify)*: _____

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional	b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional
c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional	8. DATE OF SUBMISSION *(YYMMDD)*

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