AMERICAN NATIONAL STANDARD

American National Standard

ANSI C29.13-2000

American National Standard

for Insulators—

Composite—
Distribution Deadend Type

NEMA
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
1300 NORTH 17TH STREET, SUITE 1847, ROSSLYN, VA 22209
(703) 841-3200 FAX: (703) 841-3300

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Composite—Distribution Deadend Type

Secretariat

Institute of Electrical and Electronics Engineers
National Electrical Manufacturers Association

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American National Standards Institute, Inc.

American National Standard

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FOREWORD (This foreword is not part of American National Standard C29.13-2000.)

This first edition of this standard was based on a NEMA proposed standards publication for composite distribution insulators used on overhead transmission lines. It was developed at the request of the American National Standards Committee on Insulators for Electric Power Lines, ASC C-29.

This standard was processed and approved for submittal to ANSI by ASC C-29. Committee approval of the standard does not necessarily imply that all committee members voted for approval. At the time it approved this standard, the ASC C-29 Committee had the following members:

R. Harmon, **Chairman**
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TABLE OF CONTENTS

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Tables:

Figures:

for Insulators—

Composites—Distribution Deadend Type

1 Scope

This standard covers composite distribution deadend insulators made of a fiberglass-reinforced resin matrix core, polymer material weathersheds, and metal end fittings intended for use on overhead lines for electric power systems, 69 kV and below. Mechanical and electrical performance levels specified herein are requirements for new insulators.

2 Definitions

See Section 3 of *American National Standard for Composite Suspension Insulators for Overhead Transmission Lines—Tests,* ANSI C29.11, and Section 2 of *American National Standard Test Methods for Electrical Power Insulators*, ANSI C29.1, for definition of terms.

3 General

Insulators shall conform in all respects to the requirements of this standard. The text and figures supplement each other and shall be considered part of this standard.

3.1 Drawings

Manufacturer's drawings, if furnished, shall show the outline of the insulators, together with all pertinent electrical characteristics, mechanical characteristics, leakage distance, and dimensions. Any variations in these dimensions due to manufacturing tolerances shall be indicated.

4 Materials

4.1 Core

The core of the insulator shall consist of a fiberglass-reinforced resin matrix. The core shall be sound and free of defects that might adversely affect the mechanical or electrical properties of the insulators.

4.2 Weathersheds

The weathersheds shall be made of polymer materials such as ethylene propylene or silicone elastomers. They may contain inorganic fillers and organic compounding agents.

4.3 Metal parts

Metal parts, except for cotter keys, shall be made of a commercial grade of malleable iron, ductile iron, steel, aluminum, bronze, or brass. All ferrous parts, other than stainless steel, shall be galvanized in accordance with the specification for *Zinc Coating (Hot-Dip) on Iron and Steel Hardware*, ASTM A153. Cotter keys shall be made from cold-drawn bronze, brass, or austenitic stainless steel wire.

5 Dimensions and Characteristics

Dimensions and characteristics of the insulators shall be in accordance with the manufacturer's drawings and Figure 1 and Table 2. The shapes of the weathersheds and spacing between them are not a part of this standard. For instances where specific tolerances on dimensions are not indicated, tolerances shall be as specified in Clause 5 of ANSI C29.11.

6 Marking

Each insulator unit shall bear symbols identifying the manufacturer and the year of manufacture. In addition each insulator unit shall be marked with the specified mechanical load rating (SML) with appropriate units. The markings shall be legible and durable.

7 Prototype Tests

Prototype tests are required to verify the suitability of the materials and method of manufacture for insulators defined by the following characteristics:

(1a) same shed material
(1b) same housing material
(2a) same shed design (includes diameter, thickness, and shape)
(2b) same housing design (includes thickness and covering of metal fittings)
(3) same core material
(4) same core diameter
(5) same manufacturing process
(6) same metal fitting material
(7a) same metal fitting connection zone design
(7b) same metal fitting coupling design
(7c) same core-metal-housing interface
(8) same metal fitting method of attachment to core

To allow for manufacturing variations, (2) and (4) may vary up to 15% before the design tests must be repeated, except as noted below.

Retesting is not required for greater thickness of the shed or housing or increased core dimensions. Retesting is also not required for a longer connection zone. Retesting is required for an increase in strength ratings.

The materials and methods of manufacture for insulators shall be qualified by successful completion of the following tests. Design changes shall be tested as listed in the table above.

Table 1 – Prototype testing requirements

If the insulator design changes the	Then the following design prototype tests shall be repeated:									
	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	7.10
(1a) Shed Material	X	X				X				X
(1b) Housing Material	X	X		X	X	X			X	X
(2a) Shed Design						X				
(2b) Housing Design	X				X	X			X	
(3) Core Material	X		X		X		X	X	X	
(4) Core Diameter			X		X		X	X	X	
(5) Manufacturing Process	X	X	X	X	X	X	X	X	X	
(6) Metal End Fitting Material	X				X		X	X	X	
(7a) Metal End Fitting Connection Zone Design					X		X	X	X	
(7b) Metal End Fitting Coupling Design							X	X		
(7c) Core-housing-metal End Fitting Interface Design	X				X	X			X	
(8) Metal End Fitting Method of Attachment to Core	X				X		X	X	X	

7.1 Water penetration test

7.1.1 Test specimens

Select three insulators (sample insulators) for this test and an additional identical insulator (reference insulator) for the power frequency voltage test.

7.1.2 Test procedure

Measure the hardness of two sheds of all three sample insulators in accordance with ASTM D2240 with a Shore A durometer.

Boil each sample insulator in water having 0.1% by weight of NaCl for 100 hours.

At the end of boiling, allow each insulator to remain in the water until the water cools to 50° C ± 5K. Maintain this temperature of the water until the following tests start. All tests shall be completed within 48 hours.

The sample insulators shall be rinsed with de-ionized water prior to the test evaluation.

7.1.3 Test evaluation

Visual Examination

- Inspect the housing of each sample insulator.
- There shall be no cracks and no signs of dissolving or crumbling.

Hardness Test

- Measure the hardness of two sheds of each insulator in accordance with ASTM D 2240 with a Shore A durometer at the same temperature ±5K that the pre-boiling measurements were taken.
- The hardness must not change from the pre-boiled specimen by more than 20%.

Steep-Front Impulse Voltage Test

- Subject each sample insulator to a steep-front impulse of at least 1000 kV/micro-second in accordance with 7.2.7 of IEEE Std 4. Each insulator must be subjected to 10 positive impulses and 10 negative impulses.
- Each impulse must cause an external flashover.
- Punctures must not occur.

Power Frequency Voltage Test

- Determine the power frequency flashover voltage, in accordance with the procedure described in Clause 7.1.2 of ANSI Standard C29.11, using the reference insulator, to establish a typical pre-test flashover value.
- The three aged sample insulators shall be tested and evaluated in accordance with 7.1.6.3 of ANSI C29.11.

  The average flashover value for each sample insulator shall equal or exceed 90% of the average flashover value of the reference insulator.

  Each sample insulator shall be subjected to a voltage equal to 80% of the average flashover value of the reference insulator. This voltage must be maintained for 30 minutes. No puncture shall occur. The temperature rise of the shank of each sample insulator (measured immediately after the test) shall no be more that 20°C above ambient.

7.2 Aging or accelerated weathering test

7.2.1 Test specimens

Select three new specimens of shed and housing materials for this test (with markings included, if applicable).

7.2.2 Test procedure

Test each specimen for 1000 hours by one of the following test methods. Any markings must be directly exposed to UV light.

- Xenon-Arc Methods: ASTM G 26 or ASTM D2565
- Fluorescent UV Method: ASTM G 53.

Note: Tests without water are not permitted.

7.2.3 Test evaluation

Surface cracks and blisters are not permitted and markings must be legible.

7.3 Dye penetration test

7.3.1 Test specimens

Ten samples shall be cut from an insulator. The length of the samples shall be 10 mm ± 0.5 mm. They shall be cut 90 degrees to the axis of the core with a diamond-coated circular saw blade under cool running water. The cut surfaces shall be smoothed with a 180-grit abrasive cloth. The cut ends shall be clean and parallel.

7.3.2 Test

The samples shall be placed on a layer of steel or glass balls in a glass vessel with the fiber vertical. The balls shall be of the same diameter and in the range of 1 mm to 2 mm. The dye, composed of 1 gram of fuchsin in 100 grams of methanol, is poured into the vessel until its level is 2 mm to 3 mm above the top of the balls.

7.3.3 Evaluation

The time for the dye to rise through the samples by capillarity shall be more than 15 minutes.

7.4 Water diffusion test

7.4.1 Test specimens

Six samples shall be cut from an insulator. The length of the specimens shall be 30 mm ± 0.5 mm. They shall be cut 90 degrees to the axis of the core with a diamond-coated circular saw blade under cool running water. The cut surfaces shall be smoothed with a 180-grit abrasive cloth. The cut ends shall be clean and parallel.

7.4.2 Prestressing

The surfaces of the specimens shall be cleaned with isopropyl alcohol and filter paper immediately before boiling. The specimens shall be boiled in deionized water with 0.1% by weight NaCl in a glass container for 100 hours ± 0.5 hours. Only one core material may be boiled at one time.

After boiling, the specimens shall be removed from the salt water and placed into tap water in a glass container at room temperature for at least 15 minutes.

The following test shall begin within 3 hours of removal of the specimens from the salt water.

7.4.3 Test

The test arrangement is shown in Figure 5. Immediately before the test, the specimens shall be removed from the water and their surfaces dried with filter paper. The specimens shall be placed between the electrodes and the voltage increased at a rate of approximately 1 kV per second to a value of 12 kV where it shall remain for 1 minute.

7.4.4 Evaluation

No puncture or surface flashover is allowed. The current during the whole test shall not exceed 1 mA r.m.s.

7.5 Power arc test

7.5.1 Test specimens

Three insulators shall be tested.

7.5.2 Test procedure

Each insulator shall be loaded in tension to 3000 lbs. That load shall be maintained for the duration of the test.

An arc shall be initiated across each insulator by a copper shorting fuse wire. The arc shall burn 15 to 150 cycles. The current magnitude (I x t) shall equal or exceed 150 kA-cycles.

7.5.3 Test evaluation

The test is passed if each insulator passes the moisture penetration test defined in Clause 7.5.3.1 of this specification.

7.5.3.1 Moisture penetration test

Submerge both ends of each insulator in dye composed of 1 gram of fuchsin in 100 grams of methanol for a minimum of 15 minutes.

Remove the insulators from the solution and wipe dry.

Cut each insulator 90° to the axis of the core and about 50 mm from each metal fitting. Cut both metal fittings on each insulator longitudinally in half and remove the portion of metal fitting.

The test is passed if there is no evidence of dye on the core rod of each of the samples.

7.6 Tracking and erosion test

7.6.1 Test specimens

Select three sample insulators for this test and an additional identical reference insulator.

7.6.2 Test procedures

The test circuit shall be configured such that no more than a maximum voltage drop of 5% occurs when the circuit is loaded with a resistive current of 250 mA (r.m.s.) on the high voltage side.

Test the three sample insulators using one of the two methods listed below. The manufacturer shall select the test method.

For either test method, the test may be interrupted for maintenance for a period of up to 8 hours with the cycle remaining valid. Maintenance time shall not be included in the cumulative test time.

Method 1:

The saline solution sprayed shall consist of de-ionized water with 0.22 $\pm$ 0.01 g/l of NaCl.

The voltage stress shall be 35 V/mm of leakage distance. Each insulator shall be exposed to 1000 hours of test with spray turned on.

The cycle speed shall be 60 $\pm$ 10 rotations/hour. Each insulator shall be sprayed with the saline solution at the bottom of the rotating cycle (see Figure 2). Spray nozzles and flow rate shall be adjusted so that each insulator is completely wetted during each cycle. The distance between the spray nozzle and the sample during spraying shall not be less than 125 mm.

After every four days of testing, the insulators shall be given a 24 hour recovery period. During this period, the spray nozzles shall be turned off, but all other features of the test will continue to operate.

Method 2:

The saline solution in the tank shall consist of de-ionized water with 1.40 $\pm$ 0.06 g/l of NaCl.

The voltage stress shall be 35 V/mm of leakage distance. Each insulator shall be exposed to 30000 cycles.

Each cycle shall consist of the insulator going through the four positions shown in Figure 3. Cycle time shall be 200 sec. ± 25 sec. with the insulator stationary no less than 80% of the cycle time. Each position shall require an approximately equal period of time.

After every four days of testing, the insulators shall be given a 24 hour recovery period. During this period, the test procedure remains unchanged except that the saline solution is removed from the dip tank.

7.6.3 Test evaluation

Each aged sample insulator is acceptable if there is no tracking or erosion to the core and no shed or housing puncture.

Immediately after the tracking wheel test, each aged sample insulator and the reference insulator shall be tested and evaluated to the following tests, which must be completed within 48 hours. The sample insulators shall be rinsed in de-ionized water prior to the following tests. The tests shall be performed in the order listed:

- Steep-front impulse voltage test detailed in Clause 7.1 of this specification (sample insulators only).
- Power frequency voltage test detailed in Clause 7.1 of this specification (sample insulators and reference insulator).

Acceptance criteria as specified in section 7.1

7.7 Tensile load test

7.7.1 Test specimens

Three insulators shall be tested.

7.7.2 Test procedures

The sample insulators shall be subjected to a tensile load that shall be increased rapidly but smoothly from zero to 75% of the specified mechanical load (S.M.L.) and then gradually increased to the S.M.L. in a time between 30 and 90 seconds. If 100% of the S.M.L. is reached in less than 90 seconds, the load shall be sustained at S.M.L. for the remainder of the 90 seconds.

7.7.3 Test evaluation

The test is passed if no failure occurs. The load shall then be increased until the insulator fails. The failure load and mode of failure shall be recorded. The historical failure loads shall justify the manufacturer's choice of S.M.L.

7.8 Torsional load test

7.8.1 Test specimens

Three insulators shall be tested.

7.8.2 Test procedures

The test shall be performed in accordance with Clause 5.1.4.2 of ANSI Standard C29.1. The load shall be applied smoothly to a minimum of 35 ft-lbs.

7.8.3 Test evaluation

Following the torsion test, all three insulators must pass the dye penetration test detailed in Clause 7.3 of this standard, except that only three samples are required from each insulator. One sample shall be cut from each end from outside the end fitting and one sample from the middle of the insulator.

7.9 Thermal mechanical test

7.9.1 Test specimens

Three insulators shall be tested.

7.9.2 Test procedures

Each insulator shall be loaded in tension to 5% of the S.M.L. for 1 minute at ambient temperature. While under load, the length of each insulator shall be measured and recorded as the reference length. This length shall include the end fittings but may exclude the couplings. The measurement precision shall be at least 0.5 mm.

Each of the three insulators shall then be subject to thermal variations from -50° C $\pm$ 5K to +50° C $\pm$ 5K while loaded in tension to 50% or greater of the S.M.L. for 96 hours. The time at each temperature shall be at least 8 hours per cycle. The thermal cycle profile is shown in Figure 4. The thermal cycle profile may be interrupted for maintenance for a period of no more than 4 hours with the cycle remaining valid. The maintenance time shall not be considered part of the cycle.

Following the thermal cycling, each insulator shall be permitted to reach the original ambient temperature and a load of 5% of the S.M.L. shall be applied in tension. The reference length shall be re-measured.

7.9.3 Test evaluation

The test is passed if the increase in length is equal to or less than 2 mm and each insulator passes the moisture penetration test detailed in Clause 7.5.3.1 of this specification.

7.10 Flammability test for the shed and housing material

7.10.1 Test procedures

This test shall be performed according to IEC Publication 60707, method FV. The test is intended to check the weathershed housing material for ignition and self-extinguishing properties.

7.10.2 Test evaluation

The test is passed if the test specimen belongs to Category FV0 of IEC Publication 60707.

8 Electrical Design Tests

Each insulator class shall be qualified by the electrical design tests. See Table 2 for requirements.
The insulator test specimens will be mounted for these tests in accordance with 3.1 of ANSI C29.1, except that the upper surface of the energized electrode shall be 4-8 inches (100-200 mm) from the connection point of the lower end fitting.

8.1 Low-frequency dry flashover test

Three insulators shall be selected and tested in accordance with 4.2 of ANSI C29.1. Failure of the average dry flashover value to equal or exceed 95% of the rated dry flashover value, as given on the manufacturer's drawing, shall constitute failure to meet the requirements of this standard.

8.2 Low-frequency wet flashover test

Three insulators shall be selected and tested in accordance with 4.3 of ANSI C29.1. Failure of the average wet flashover value to equal or exceed 90% of the rated wet flashover value, as given on the manufacturer's drawing, shall constitute failure to meet the requirements of this standard.

8.3 Critical impulse flashover tests—positive and negative

Three insulators shall be selected for the critical impulse flashover test, positive, and one for the critical impulse flashover test, negative, and tested in accordance with 4.7 of ANSI C29.1. Failure of the average critical impulse flashover value to equal or exceed 92% of the rated critical impulse flashover value, as given on the manufacturer's drawing, shall constitute failure to meet the requirements of this standard.

8.4 Radio-influence voltage

Three insulators shall be selected and tested in accordance with 4.9 of ANSI C29.1. The test voltage and maximum RIV level shall be as listed in Table 2.

9 Quality Conformance Tests

Samples for quality conformance tests shall be selected at random from the lot.

9.1 Dimensional tests

Three insulators shall be selected at random from the lot and their dimensions checked against the dimensions on the manufacturer's drawing. Failure of one or more of these insulators to conform within manufacturing tolerance to the dimensions on this drawing shall constitute failure to meet the requirements of this standard.

9.2 Galvanizing test

Three pieces representative of each type of galvanized hardware used with the insulators shall be selected at random and tested in accordance with Section 6 of ANSI C29.1. Five to ten measurements on uncrimped areas shall be randomly distributed over the rest of the surface. Both the average thickness values for each individual specimen and the average of the entire sample shall equal or exceed the following:

	Average of Entire Sample	**Average of Individual Specimen**
Hardware (except nuts/bolts)	3.4 mil	3.1 mil
Nuts/bolts	2.1 mil	1.7 mil

If the average of one specimen, or if the average of the entire sample, fails to comply with the table above, six additional pieces of the same type of hardware shall be selected at random and tested. Failure of the

retest sample to comply with the minimum thickness criteria shall constitute failure of the lot to meet the requirements of this standard.

9.3 Specified mechanical load test

Three insulators shall be selected at random from a lot offered for acceptance and tested in accordance with clause 7.7 of this specification.

9.4 Retest Procedure

If only one insulator or metal part fails to comply with the requirements of a quality conformance test, a new sample equal to twice the quantity originally submitted to that test shall be subjected to retesting. The retesting shall comprise the test in which failure occurred, preceded by those tests that may be considered as having influenced the results of the original test.

If two or more insulators or metal parts fail to comply with any of the sample tests or if any failure occurs during the retesting, the complete lot is considered as not complying with the standard and shall be withdrawn for examination by the manufacturer. The number then selected shall be three times the first quantity chosen for tests.

The retesting shall comprise the test in which failure occurred, preceded by those tests that may be considered as having influenced the results of the original test. If any insulator fails during the retesting, the complete lot is considered as not complying with this standard.

10 Routine Tests

Routine tests are to be performed on every insulator produced.

10.1 Tension-proof test

Each assembled insulator shall withstand for at least 10 seconds a tensile load equal to or greater than the routine test load (R.T.L.) rating.

10.2 Visual examination

The mounting of the metallic parts shall be in conformance with the manufacturer's drawing. The following imperfections shall be acceptable on the insulator surface: superficial defects of area less than 25 square millimeters (the total defective area not to exceed 2% of the total insulator surface) and depth less than 1 mm.

11 References to the Text

11.1 Reference to American National Standards

When the following American National Standards referred to in this document are superseded by a revision approved by the American National Institute, Inc., the revision shall apply:

American National Standard Test Methods for Electrical Power Insulators, ANSI C29.1-1996.

American National Standard for Composite Suspension Insulators for Overhead Transmission Lines—Tests, ANSI C29.11-1996.

11.2 Reference to other than American National Standards

Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware, ASTM A153-1995.

Test Method for Rubber Property—Durometer Hardness, ASTM D2240-95.

Practice for Operating Light-Exposure Apparatus (Xenon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials, ASTM G26-95.

Practice for Operating Xenon Arc-Type Light-Exposure Apparatus With and Without Water for Exposure of Plastics, ASTM D2565-92a

Practice for Operating Light and Water–Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure of Nonmetallic Materials, ASTM G53-95.

Methods of Test for the Determination of the Flammability of Solid Electrical Insulating Materials when Exposed to an Igniting Source, IEC 60707.

IEEE Standard Techniques for High-Voltage Testing, IEEE Std 4-1995.

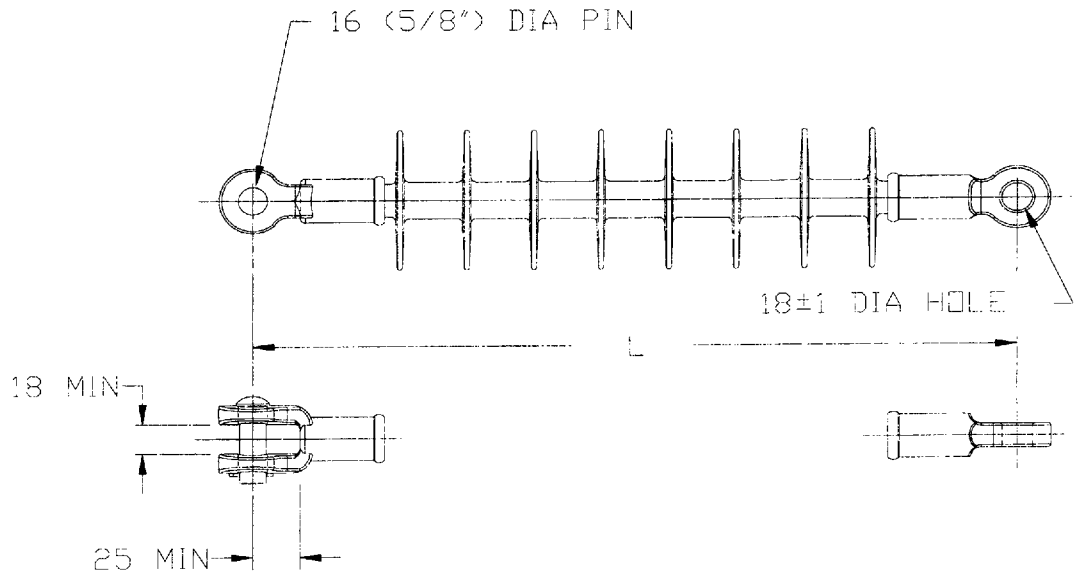

Figure 1 – Composite—Distribution Deadend Insulator

NOTE:
Dimensions are given in mm unless otherwise noted.
This is a pictorial representation. The number and shape of weathersheds may vary. Dimensions not detailed vary by manufacturer.
End fitting design and method of attachment to the core vary by manufacturer.

Table 2 – Design Requirements

REQUIREMENTS	UNITS	INSULATOR CLASS				
		DS-15	DS-28	DS-35	DS-46	DS-69
DIMENSIONS						
Section Length L	mm	330±15	430±25	525±60	590±50	750±75
Min. Leakage Distance	mm	355	550	730	900	1190
ELECTRICAL RATINGS						
Low-Frequency Dry Flashover	kV (rms)	90	130	145	180	220
Low-Frequency Wet Flashover	kV (rms)	65	100	130	145	185
Positive Critical Impulse Flashover	kV (peak)	140	190	250	280	360
Radio-Influence Voltage						
Test Voltage	kV (rms)	15	20	30	30	45
Max. RIV @ 1000 kHz		10	10	10	10	10
MECHANICAL RATINGS						
Min. S.M.L.	LB	10,000	10,000	10,000	10,000	10,000
Min. Torsional Load	FT-LB	35	35	35	35	35

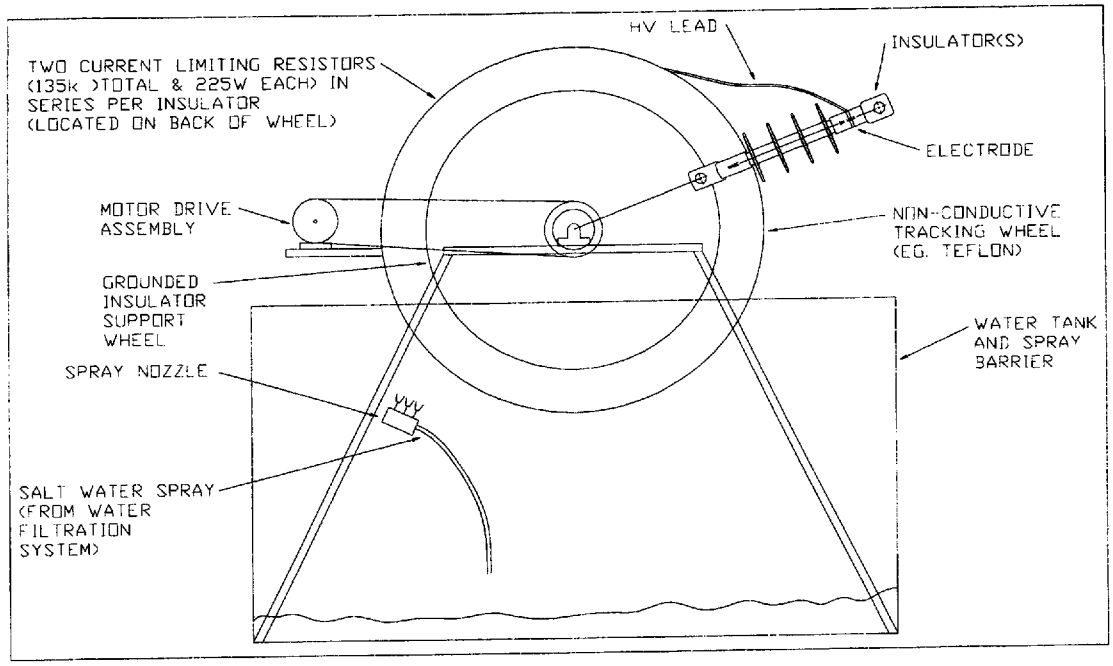

Figure 2 – Tracking and Erosion Test; Method 1

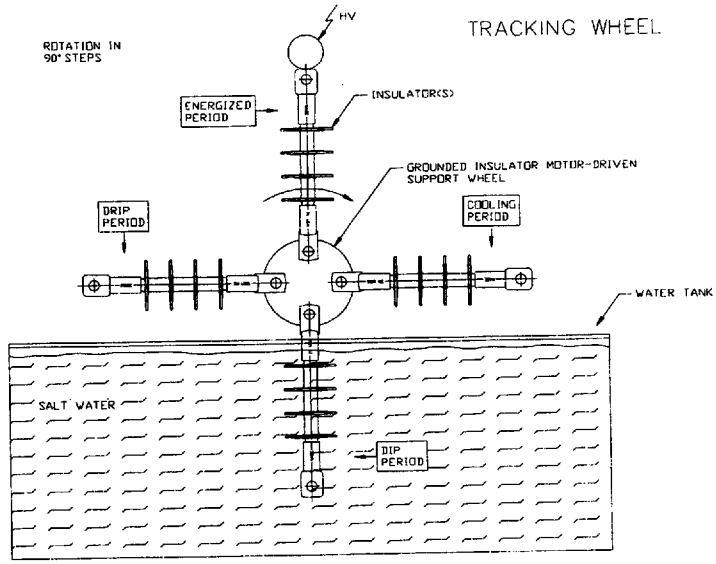

Figure 3 – Tracking and Erosion Test; Method 2

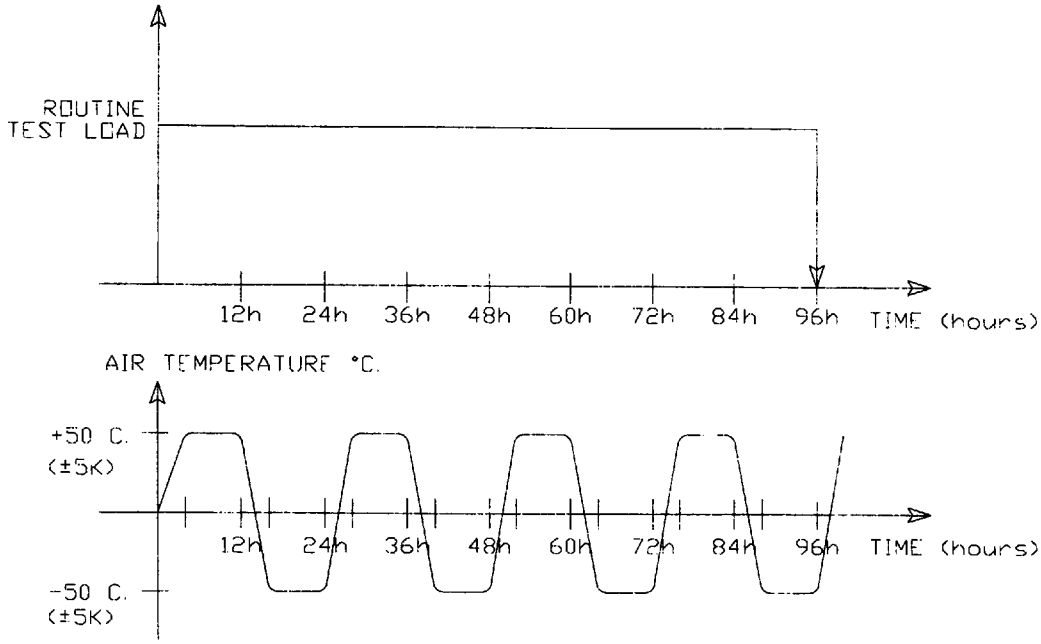

Figure 4 – Thermal Mechanical Load Test

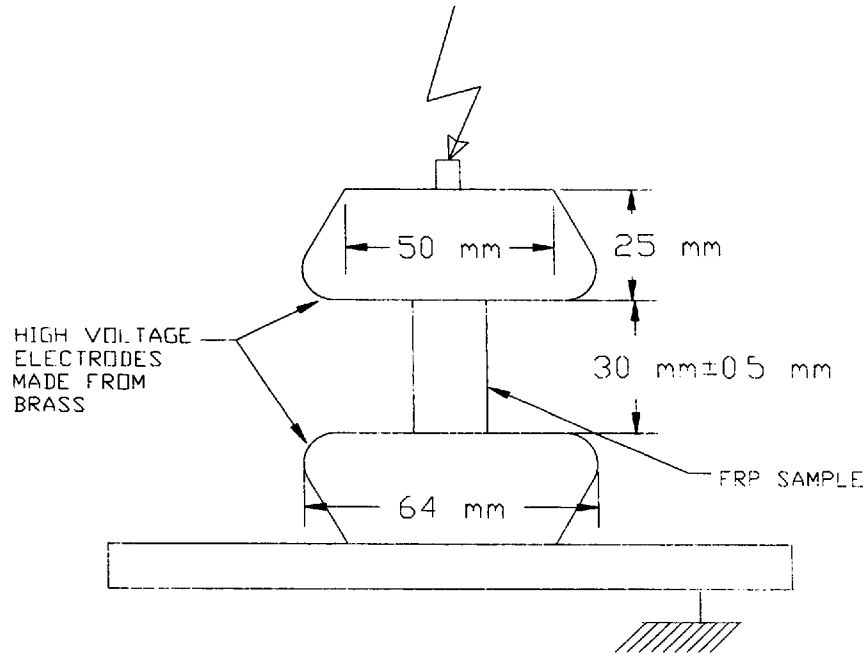

Figure 5 – Electrodes for Clause 7.4