Polymer Insulator Specification:
69 kV Through 765 kV

1. SPECIAL CONDITIONS FOR EACH RFQ

The Owner will indicate in the RFQ any of the following special conditions:

1.1.1 If the procurement covers insulators only or complete insulator-hardware assemblies

1.1.2 The voltage class(es) and ampacities required, where applicable

1.1.3 If Charpy certification is required and to what level

1.1.4 If Magnetic Particle Inspection (MPI) is required on ferromagnetic hardware as a standard deliverable or only when triggered

1.1.5 The inspection regime, if any: Owner witness, hold points, ITP review, independent testing rights, and required report forms

1.1.6 If preproduction and/or pre-shipment proof-of-fit is required

1.1.7 If there are any source-country or Manufacturer restrictions, and if BABA, Buy American, Federal Acquisition Regulation (FAR) domestic preference, USDA RUS, or any other federal, state, or local content or assembly clauses apply

1.1.8 If kitting by assembly is required or if standard packaging is acceptable

1.1.9 Corona and RIV performance requirements, if any — voltage class threshold, test method, RIV limits, and number of assemblies to be tested

1.1.10 If certified test reports are required and how many copies

1.1.11 If spare hardware (nuts, bolts, U-bolts, cotter pins) is required, if it is to be shipped complete with the first assemblies, and the percentages required

1.1.12 If the Manufacturer shall make available a qualified field technician for advice and technical support during handling and installation

2. SCOPE

This specification covers the technical aspects of manufacture, testing, and delivering of composite insulators used on overhead transmission lines.

3. DEFINITIONS

3.1.1 Cantilever Breaking Load (CBL) - the maximum load reached during destructive testing.

3.1.2 Core - The internal part of a composite insulator. The core is both the mechanical load-bearing component and electrical withstand component of the insulator. The core consists mainly of glass fibers impregnated with a resin-based matrix so as to achieve maximum strength. Also called a fiberglass-reinforced plastic (FRP) rod.

3.1.3 Damage Limit – The load at which the insulator begins to exhibit permanent change from its original strength rating. These changes include stretching or breakage of individual glass fibers within the core, elongation of deformation of metal end fittings.

3.1.4 Dry-Arc Distance – The shortest distance from one end of the insulator through the surrounding medium (typically air) to the other end.

3.1.5 End Fittings, Metal – The metal attachment hardware that is connected to the insulator core that transmits the mechanical loads to the core at the ends of the insulator.

3.1.6 EPDM (Ethylene Propylene Diene Monomer) – Previously used as a base polymer in nonceramic composite insulator rubber formulations.

3.1.7 EPR (Ethylene Propylene Rubber) - The generic term that includes both EPDM and EPM.

3.1.8 Grading Device, Grading Ring, Corona Ring - a conductive metal device that alters the electrical fields around an end-fitting or hardware with the intent to mitigate corona or reduce the electric field.

3.1.9 Housing – The rubber component that entirely encapsulates and protects the core rod of the insulator.

3.1.10 Leakage Distance – The shortest distance between the conductive ends of the insulator as measured by tracing along the insulating surface.

3.1.11 Lot – The number of insulator units in which each constituent component of the units (core, housing, metal end fittings, etc.,) comes from the same production run and the units are assembled in the same manner and process. Each lot should, as far as is practicable, consist of units of product of a single type, grade, class, size, or composition manufactured under essentially the same conditions and in contiguous time periods. The units shall have the same Specified Mechanical Load (SML) or Specified Cantilever Load (SCL) rating.

3.1.12 Maximum Design Cantilever Load (MDCL) - The line post insulator cantilever load rating assigned by the manufacturer. The maximum load [Working Cantilever Load] that can be applied to the post insulator every day with no deleterious effect on the service life of the insulator. Some manufacturers list this rating as the Reference Cantilever Load (RCL). This load is typically equal to 50 percent of the Specified Cantilever Load (SCL)

3.1.13 Non-Ceramic Composite or Polymer Insulator - An insulator unit that is made from material other than porcelain, glass, or other ceramic material. It consists of a load-bearing resin-impregnated fiberglass core, metal end fittings, and external elastomeric housing.

3.1.14 Owner – For this specification, “Owner” means the ultimate end user. If the Owner has transacted with an Intermediary (e.g., distributor, packager, or EPC) to procure from the Manufacturer, all technical direction— including specifications, drawings, and requirements—shall be issued to the Manufacturer by the Intermediary, and all submittals and deliverables shall be provided by the Manufacturer to the Intermediary. Only the product warranty transfers from Manufacturer to the Owner.

3.1.15 Post Insulator - Primarily intended to be loaded in a cantilever mode, although specific applications may require loading in tension or compression. The most common types are: (1) horizontal line post where the insulator projects nearly horizontally from a structure and is loaded in bending by the conductor, (2) braced line post or horizontal Vee application, and (3) a station post insulator used as a bus support in an outdoor substation. Post insulators used in disconnect switch applications may also be loaded in torsion.

3.1.16 Reference Cantilever Load (RCL) – One half the SCL rating, sometimes listed as the Maximum Design Cantilever Load (MDCL).

3.1.17 Routine Test Load (RTL) – A proof-test load applied to every composite insulator that is equal to or greater than 50 percent of the insulator Specified Mechanical Load (SML) or Specified Tensile Load (SMT). Considered to be the maximum continuous working load of the insulator.

3.1.18 Section Length (SL) – In a suspension insulator, the SL is the straight-line distance between the attachment points of the coupling zones at either end of the insulator. In a line post insulator, SL is the straight-line distance from the support structure face to the line attachment point of the coupling zone.

3.1.19 Silicone Rubber (SR) - Usually in the form of polydimethylsiloxane, SR is used as a base polymer in non- ceramic composite insulator rubber formulations. It is known for its hydrophobic (water-repellent) properties.

3.1.20 Specified Cantilever Load (SCL) - A load specified by the manufacturer that represents the minimum breaking load of a line post insulator under cantilever loading. The strength should be verified during cantilever load tests, and the historical failure loads (CBL) should justify the manufacturer’s choice of SCL. The SCL forms the reference point for selection of a composite line post insulator. It is not the maximum working load of the insulator. See MDCL.

3.1.21 Specified Mechanical Load (SML) - A load specified by the manufacturer that represents the ultimate strength of a suspension insulator under tension. The strength should be verified during Mechanical Load Tests, and the historical failure loads should justify the manufacturer’s choice of SML. It forms the reference point for selection of a suspension insulator. SML may be reduced by the class of hardware used for the end fittings.

3.1.22 Specified Tensile Load (STL) - The load specified by the manufacturer which represents the ultimate strength of a line post insulator under tension. The strength is verified by the same testing procedures used to determine the Specified Mechanical Load (SML) for composite suspension insulators.

3.1.23 Suspension Insulator - Any insulator intended primarily to carry tension loads. It includes tangent, dead-end, and vee-string installations.

3.1.24 Test, Design - Tests to verify the characteristics of an insulator that depend on its size and shape. Tests are required only once for insulators of new design.

3.1.25 Test, Mechanical Load - A mechanical test for suspension insulators as specified in ANSI C29.11 and used to determine if a lot of insulators meet the Specified Mechanical Load (SML) requirements. The historical failure loads from this test justify the manufacturer's choice of SML. Mechanical testing is also performed on every insulator to check its Routine Test Load (RTL) rating.

3.1.26 Test, Prototype - Tests to evaluate and verify the suitability of materials, interfaces, prototype design, and method of manufacture. Prototype tests are performed only once and are considered valid for the entire class of insulators represented.

3.1.27 Test, Quality Conformance - Destructive or nondestructive tests that are used to verify insulator conformance to specific characteristics and determine acceptability of an insulator lot.

3.1.28 Test, Routine - A test performed on every insulator to identify manufacturing defects.

3.1.29 Test, Sample - A test performed on one or more insulators from a lot to identify insulators with manufacturing defects.

3.1.30 Ultimate Strength - An insulator's tensile, compressive, or cantilever loading at which any part of the insulator fails to perform its function of providing mechanical support. Damage to the insulator core is likely to occur at loads lower than the insulator failing load.

3.1.31 Weather-shed or Shed - The part of the insulator's housing which protrudes from the sheath and is used to increase the creepage distance

4. GOVERNING STANDARDS

Where this specification and a referenced standard conflict, this specification governs.

3.1 Standards

4.1.1 ANSI/NEMA C29.1 — Test Methods for Electrical Power Insulators

4.1.2 ANSI/NEMA C29.11 — Composite Insulators—Test Methods

4.1.3 ANSI/NEMA C29.12 — Composite Insulators—Transmission Suspension Type

4.1.4 ANSI/NEMA C29.17 — Composite Insulators—Transmission Line Post Type

4.1.5 ASME Y14.5.1 — Mathematical Definition of Dimensioning and Tolerancing Principles

4.1.6 ISO 9001 — Quality management systems — Requirements

4.1.7 ISO 14001— Environmental management systems

4.1.8 ISO 45001— Occupational health and safety management systems

4.1.9 ASTM A153/A153M — Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

5. DESIGN AND MANUFACTURING REQUIREMENTS

The design, fabrication, processes, tolerances, and inspection of Insulators shall conform to the following:

5.1 Language and Units

5.1.1 All correspondence, literature, drawings, test data, and markings shall be in the English language.

5.2 Design and Material Requirements

5.2.1 The internal core shall consist of a FRP rod consisting of boron-free E-glass fibers and epoxy-based resin. All fibers of the insulator core shall be fully and completely coated with the epoxy resin matrix. During fabrication of the insulator core, the glass strands in the insulator core shall not be allowed to touch one another without resin matrix surrounding each individual fiber. Fibers shall be continuous between rod ends and oriented parallel to the rod axis. Glass content shall equal or exceed 60 percent by volume of the fiberglass-epoxy mixture. All areas in the rod not occupied by fiberglass strands shall be filled with epoxy. All fiberglass strands and epoxy shall be fully bonded together.

5.2.2 The insulator core shall be mechanically and electrically sound, free from voids, foreign substances, and manufacturing flaws. The core shall be concentric and straight throughout the entire length of the rod.

5.2.3 The core shall be completely covered by a continuous housing of a sheath-weather-shed system using either a single-shot high temperature vulcanization (HTV) injection molding or an extrusion process followed by high temperature curing of sheds to sheath using a crosslinking agent. The housing shall fully protect the fiberglass rod for the service life of the insulator. For a molding process, the weather-shed system shall be bonded to the prepared fiberglass rod such that the silicone fully encapsulates the entire rod in one single and continuous cycle. Multiple shots, jumps, or cycles to make a single insulator are not allowed. The housing shall be smooth and free from imperfections, notwithstanding mold parting lines and pin ejection points.

5.2.4 The polymer housing shall be bonded to the rod before crimping the end-fittings to eliminate the potential of heat relaxing the crimp – molding over crimped end fittings is not allowed. The housing shall be made with a silicon-based polymer compound – EPDM, EPR, or associated mixtures are not allowed.

5.2.5 The housing shall have a concentric radial thickness no less than 3.0 mm along the entire length of

the housing. The housing shall be fully bonded over the entire length of the insulator, and the bond strength must be greater than the tearing strength of the housing. Housing shall have a uniform color and consistency.

5.2.6 The complete insulator shall be designed to mitigate water droplet corona. Stacked sheds are an acceptable method of mitigation.

5.2.7 Materials and methods used in the fabrication of metal parts shall be selected to provide proper strength and ductility. Metal castings, steel bases, and all end fittings shall be made from iron or forged steel and shall be hot-dipped galvanized in accordance with ASTM A153, "Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware." End fittings and bases shall be uniform and without sharp edges or corners and shall be free of cracks, flakes, slivers, slag, blow-holes, shrinkage defects, and localized porosity.

5.2.8 End fitting attachment to the FRP rod shall be performed with a symmetrically controlled automated crimping method that compresses the metal radially onto the rod without damage to the rod fibers or resin matrix while providing a strength equal to or greater than the defined and specified ultimate strength of the insulator. Acoustic monitoring of the crimping process is not an acceptable method for confirming crimp quality. Manual and non-radial crimping shall not be allowed.

5.2.9 Each insulator shall have a compression-based seal at the interface between the metal end fittings and the housing to prevent moisture and foreign materials from entering over a fifty-year life. The metal end fittings and the housing after complete assembly shall be coaxial with one another and with the core, resulting in no eccentric loading. Galvanization must be on the sealing surface.

5.2.10 Cotter keys shall be grade 304L stainless steel (minimum grade). Bolts, nuts, and spring lock washers shall be made of steel and hot-dipped galvanized in accordance with ASTM A153, unless otherwise specified. Bolts may have either rolled or cut threads and shall have thread engagements capable of developing the specified strength of the unit. Nuts may be re-threaded after galvanizing to ensure clean threads, but bolts shall not be threaded or re-threaded after galvanizing.

5.2.11 Threaded holes and nut threads shall be tapped oversize to closely fit those of the galvanized bolt with no unnecessary looseness, but free enough to permit the nut to be turned on freely with the fingers over the entire thread length.

5.2.12 Suspension and line post insulators operated at 230 kV and above require a grading device at the energized end of the insulator, and rings shall be provided at both ends of the insulator at and above 500kV. Owner shall specify in the request for quote if corona rings are desired for 161kV and below.

5.2.13 The size and placement of the grading device shall be designed by the manufacturer to minimize corona along the entire length of the insulator at 105% of nominal line-to-ground voltage.

5.2.14 Corona rings shall be designed for installation with hot line tools and shall be unidirectional to eliminate the possibility of being installed upside down/backwards. Corona rings shall allow for up

to 45 ft-lbs. of torque during installation to ensure secure fit to prevent rotation or loosening.

5.2.15 All parts must be designed to perform in ambient temperatures ranging from -40F to 130F.

5.2.16 Insulator manufacturer and plant shall have been actively engaged in supplying insulators to the US market continuously for at least 20 years.

5.3 Materials and Workmanship

5.3.1 Materials specified in the design and fabrication requirements of this specification shall be unused and free of defects or irregularities.

5.3.2 All components of the same design and designation shall be identical, and like components shall be interchangeable.

5.4 Markings

5.4.1 All suspension insulators shall be clearly and permanently marked on the top shed or an end fitting with the following information:

- Manufacturer's Name or Trademark
- Year Manufactured
- Specified Mechanical Load (SML) in pounds
- Routine Test Load (RTL) in pounds and identified by the word "TEST" or "RTL"
- Lot Number

5.4.2 All line post insulators shall be clearly and permanently marked on the line side shed or end fitting with the following information:

- Manufacturer's Name or Trademark
- Year Manufactured
- Specified Cantilever Load (SCL) in pounds
- Maximum Design Cantilever Load (MDCL) or Reference Cantilever Load (RCL) in pounds
- Lot Number

5.4.3 The manufacturer shall keep documented records describing the insulator information and lot numbers for each insulator.

6. INSPECTION AND TESTING

6.1.1 Insulator testing on units applied at 45kV and above shall be performed in accordance with procedures as specified in ANSI C29.11 and C29.12, and ANSI C29.17 (except for deflection, galvanization, and dimensional sample tests) when not otherwise indicated herein.

6.1.2 The Owner shall state at time of request for quotation if ANSI C29.17 deflection, galvanization, and dimensional tests are required since inspection incurs additional testing costs. If not specified within the RFQ, the Manufacturer shall follow its standard QC/QA process.

6.1.3 Design testing is only required to be performed once on complete, full-scale insulators for a

specific electrical design. If requested and under a non-disclosure agreement, the manufacturer shall provide the owner with copies of such certified testing, evaluation, and acceptance reports. If requested and agreed upon in advance between Owner and Manufacturer, design testing can be performed at a third-party lab, subject to lab capabilities.

6.1.4 Requests for quality Certificates of Conformance (COC) and/or sample test reports shall be made at time of request for quote and shall reference the applicable standards.

6.1.5 Routine testing shall be performed on every insulator unit produced for procurement under this request and shall be performed under ANSI standards.

6.1.6 Production or sample test reports, if required, shall be requested by the Owner in the RFQ and at the time of order.

7. DELIVERABLES – DOCUMENTATION, DRAWINGS

7.1.1 At time of the quote the Owner will indicate which documents must be approved by the Owner before fabrication begins.

7.1.2 When requested, all documentation will be submitted electronically. Document format shall be in PDF and/or Microsoft Excel formats as appropriate. Transmission insulator load curves shall be supplied in PLS-CADD™ electronic format.

7.1.3 Standard drawings and documents shall include the following information:

- Warranty Information
- Applicable Deflection and Combined Loading Application Curves
- Grading Device Size, Mounting, Orientation, and other installation Information
- Connection Length
- Number of Sheds
- Dry Arc Distance
- Leakage Distance
- Approximate Weight
- Low-Frequency Dry Flashover
- Low-Frequency Wet Flashover
- Critical Impulse Flashover Positive
- Critical Impulse Flashover Negative
- For Suspension Insulators:
  1. Specified Mechanical Load
  2. Routine Test Load
- For Line Post Insulators:
  1. Specified Cantilever Load
  2. Maximum Design Cantilever Load or RCL
- End Fitting Material
- Size and Dimension Details for Both End Fittings
- Manufacturer's Catalog Number
- Manufacturer's Drawing Number with latest revision

7.1.4 Owner will indicate at time of RFQ if and what project schedule documentation is required.

7.1.5 Owner will indicate at time of RFQ if an electric field test or model is required. If required, owner will provide to the Manufacturer the structure configurations, conductor configuration, and any third-party's related drawings.

7.1.6 Owner will indicate at time of RFQ if Manufacturer shall carry out corona or RIV lab tests or if another party will carry out tests. Owner will clearly delineate the responsibilities of parties in testing and to each other.

7.1.7 If Manufacturer is responsible for electrical testing, Owner will provide their maximum acceptable electrical thresholds. The Manufacturer, on the basis of historical data and established experience, shall assess to a high degree of confidence that the electrical performance of insulator/hardware assemblies, when evaluated under laboratory conditions, will remain below (a) thresholds generally recognized within applicable industry standards, and (b) those thresholds established by the Owner or Owner's Engineer. On this basis, and when requested in RFQ, the Manufacturer will undertake the responsibility for testing the relevant assemblies for corona and radio interference voltage (RIV) performance and report the results obtained. If such electrical performance exceeds the thresholds established by the Owner, the Manufacturer shall engage with the testing laboratory and the Owner to review and, where reasonably practicable, modify the assembly design with the objective of improving electrical performance.

7.1.8 Notwithstanding the foregoing, it is expressly understood that the Owner or Owner's Engineer retains sole responsibility for determining the suitability and adequacy of the specified mechanical ratings and demonstrated laboratory electrical performance for the project, including with respect to the intended application, geographic region, and in-service environmental conditions.

7.1.9 It is also understood that any assembly installation undertaken prior to acceptance of electrical test results by the Owner is performed at the sole risk of others. The granting of permission, or lack of objection, by the Manufacturer to proceed with such installation will not be construed as acceptance of the works, nor as an assumption of any associated risk or liability. Any risks to the project arising from installation prior to acceptance of electrical test results—including, but not limited to, risks of non-conformance, rework, or material modification—shall rest exclusively with others. Notwithstanding the foregoing, should it be determined that assembly installation completed prior to such acceptance requires modification, replacement, or rework to achieve compliance with project requirements, all such corrective measures shall be undertaken at no cost or liability to the Manufacturer.

8. PACKAGING AND SHIPPING

8.1 Insulator Packaging

8.1.1 Insulators shall be packaged in fully enclosed wooden crates. Insulators banded to open pallets or enclosed in crate frames with sides made only of shrink-wrap, plastic, or materials other than plywood or pressboard will not be accepted.

8.1.2 Crate frames shall be constructed from nominal 2x4 lumber forming a base perimeter, corner

posts, and top perimeter with either plywood or pressboard completely covering the frame on all sides. Corner posts shall be doubled 2x6s or larger with gussets and intermediate 2x4 uprights as needed for strength and rigidity. Intermediate vertical studs shall be provided as needed so that pressboard or plywood panels are fully supported. Crate frame shall use solid, kiln-dried or equal, straight, sound, and free of splits or knots in critical areas. Crate sides, top, and bottom shall be OSB or plywood. Plywood sides shall be used when longer storage is requested by the Owner or when the weight on the bottom side requires reinforcement.

8.1.3 Crates shall not exceed 2500lbs in gross weight.

8.1.4 All internal bracing securing heavy items shall use 2 or more screws on each end. Manufacturer may use one screw on each end of internal hold-down bracing of lightweight materials if it deems appropriate. Fasteners shall have pull-through prevention heads when fastening through pressboard or plywood.

8.1.5 Lid shall be designed for multiple, controlled openings and closings using original screws and screw locations. Lid shall be secured with screws having the same head for the entire crate. Screws heads shall be standard sized Square, Phillips, or Torx heads. Lid screws shall be spaced 16-24 inches on the crate ends and every 24-48 inches on the crate sides. 1 screw shall be used to secure the lid at each corner and at each vertical framing board.

8.1.6 The crate must be banded with heavy-duty polyester banding – steel banding is unacceptable. Vertical banding around the crate shall be secured every 24-48” and at least one horizontal band shall be placed around the midsection. Bands shall be tight properly crimped/sealed.

8.1.7 Each crate shall be strong enough to support two additional, fully loaded crates on top while resting on level dirt or crushed rock. Stacking loads shall transfer through corner posts/uprights, not through panels.

8.1.8 Crate base shall resist racking, fork, and sling point loads without bottom panel failure. Base shall provide minimum of 2-way standard fork pockets and have a ground clearance suitable for outdoor storage.

8.1.9 If the crates/containers are stacked during transport, they must be properly designed, constructed, stacked, and strapped to prevent damage due to sudden impacts.

8.1.10 Packaging shall safeguard all transporters, handlers, and the public from falling, shifting, or settling materials and from any sharp edges.

8.1.11 Fasteners, such as nails, screws, bolts, and staples shall be of proper length such that ends are not exposed either internally or externally to cause potential safety or material hazards.

8.1.12 Materials shall be loaded so that the combined center of gravity (CG) of the crate and contents remain between the fork pockets/skids. Weight shall be distributed symmetrically keeping the heaviest items low and directly over the base runners.

8.1.13 All materials and boxes inside the crate shall be packaged and secured safely to prevent tipping,

sliding, or exiting their packaging during vehicular acceleration, deceleration, swerving, or emergency braking.

8.1.14 Loose parts shall be contained internally and secured with 2x3 or larger bracing. If mixed parts are shipped, small components shall be segregated and secured to prevent migration into other parts. Other than packing materials, there shall be no unnecessary loose materials in the crate.

8.1.15 All hardware designed to minimize corona shall be protected to prevent being nicked, cut, scraped, or worn during transport. Aluminum components shall be segregated to protect them from being damaged by ferrous hardware. Ferrous hardware shall likewise be packed to prevent any damage to its galvanized coating.

8.1.16 Container fasteners and hardware shall not touch any part of the insulators. Insulators shall not rest against each other or against the crate in a way that could damage the insulators.

8.1.17 The bottom and top layer of suspension insulators shall be supported by the insulator end fittings resting on 2x3 or larger support members. Ends shall be secured or nested to prevent moving in any axis during transport. Top and bottom insulators greater than 120" shall be supported by a center crossmember and be covered with foam, cardboard, or other suitable protective material.

8.1.18 Line post insulator bases shall be secured by 2x3 or larger wooden supports on both sides of the base to prevent sliding.

8.1.19 If corona rings are shipped installed on insulators, rings shall be protected from damage and not touch the crate, crossmembers, or other components.

8.1.20 Internal packaging shall permit easy identification and counting when the crate is opened.

8.1.21 All containers, crates, and packages shall be clearly marked in English. Markings shall be clear and weather resistant when affixed to outdoor labels. Labels shall be affixed with staples on all four corners. Labels shall be placed on sides to allow for reading while stacked and while using a forklift.

8.1.22 Crates must be stored dry for at least 48 hours prior to packing to avoid condensation or fouling.

END OF SPECIFICATION