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IEEE Guide for Application of Composite Line Post Insulators

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Transmission and Distribution Committee

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IEEE Guide for Application of Composite Line Post Insulators

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of the
IEEE Power Electronics Society

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Abstract: This is a guide for the application of composite post insulators to overhead transmission and distribution lines. It is based on utility field experiences, results of research laboratory tests, and manufacturers' recommendations.

Keywords: composite line post insulators, core, end fittings, grading devices, transmission and distribution lines, weathersheds

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Introduction

(This introduction is not part of IEEE Std 1572-2004, IEEE Guide for Application of Composite Line Post Insulators.)

Composite insulators, both suspension and line post types, are being widely used by utilities for supporting and insulating electric transmission and distribution lines. Many of the characteristics of composite insulators, such as performance on standard electrical design tests, are similar to those for ceramic insulators. Some characteristics, however, are unique to composite insulators. For the line post type, an example is the response of the insulators to combined dynamic mechanical loads. Therefore, to successfully apply composite insulators, guidance is needed. This application guide provides information for composite line post insulators. It is based on service experience, laboratory tests, and manufacturers' recommendations.

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This guide was prepared by a task force of the working group on Composite Insulators, Lightning and Insulator Subcommittee, Transmission and Distribution Committee, of the IEEE Power Engineering Society. At the time this guide was initiated, George. G. Karady was the chairman of the working group. D. H. Shaffner originated as the chairman of the task force, R. Allen Bernstorf succeeded in this role, and both were instrumental in guiding development of this guide. The following is a list of participants in the task force.

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IEEE Guide for Application of Composite Line Post Insulators

1. Scope

This is a guide for the application of composite post insulators to overhead transmission and distribution lines. It is based on utility field experiences, results of research laboratory tests, and manufacturers' recommendations.

The guide deals with composite post insulators, which include a core, weathersheds, and metal end fittings. The core consists of resin and aligned glass fibers. The weathersheds are of elastomeric materials.

2. References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

Accredited Standards Committee C2, National Electrical Safety Code® (NESC®).[1]

ANSI C29.11-1989, Composite Suspension Insulators for Overhead Transmission Lines—Test.[2]

ANSI C29.17, For Insulators—Composite-Line Post Type.

IEC 61109, Composite Insulators for A.C. Overhead Lines with a Nominal Voltage Greater than 1000 V—Definitions, test methods, and acceptance criteria.[3]

IEC/TR 60815, Guide for the Selection of Insulators in Respect of Polluted Conditions.

IEEE Std 957™, IEEE Guide for Cleaning Insulators.[4]

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[1] The NESC is available from the Institute of Electrical and Electronics Engineers, Inc., 445 Hoes Lane, Piscataway, NJ 08854, USA (http://standards.ieee.org/).

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3. Definitions

For the purposed of this guide, the following terms and definitions apply. *The Authoritative Dictionary of IEEE Standards Terms*, Seventh Edition [B14], should be referenced for terms not defined in this clause.[5]

3.1 Structural terms

The following terms apply to the physical composition of the insulator.

3.1.1 base: An accessory that enables an elastomeric line post to be mounted to a pole or tower.

3.1.2 end fittings: The insulator attachment hardware that is connected to the core.

3.1.3 grading device: A device for controlling the potential gradient at the end fittings, such as a metal ring or various semiconductive devices.

3.1.4 hollow core: A fiber reinforced resin matrix, generally cylindrical or conical in shape, which surrounds a longitudinal cavity and forms the mechanical load-bearing component of a hollow insulator.

3.1.5 housing: The external elastomeric covering installed over the core to afford it protection. Depending on the design of the insulator, this covering may comprise a separate or integral sheath—weathershed system. In both cases, the weathersheds provide the wet electrical strength and leakage distance, whereas the sheath provides the core with protection between weathersheds and near the end fittings.

3.1.6 post insulator: An insulator with attached metal parts having a means for direct and rigid mounting on structures and for semirigidly supporting line conductors.

3.1.7 section length: The distance from the primary mounting features or coupling zones from one end of an insulator to the other end, as defined by the manufacturer.

3.1.8 solid core: The axially aligned fiber-reinforced resin rod that forms the mechanical load-bearing component of the insulator.

NOTE—This guide deals with solid and hollow core insulators.[6]

3.2 Electrical terms

The following terms apply to electrical phenomena that may occur on housing/weathershed material during service.

3.2.1 chalking: The residual inorganic materials remaining on the surface of an elastomeric material after ablation of the organic portions of the material.

3.2.2 corona cutting: A scissioning or splitting of the elastomer resulting from the exposure of the elastomer to localized high levels of ultraviolet energy associated with the presence of corona.

3.2.3 crazing: Regular surface fissures in the elastomer with a depth less than 0.1 mm, but with an associated geometric pattern.

3.2.4 cracking: Surface fissures in the elastomer with a depth greater than 0.1 mm.

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[5] The numbers in brackets correspond to those of the bibliography in Annex A.

[6] Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement the standard.

3.2.5 erosion: The loss of material by the physical action of leakage current, corona discharge, or dry band arcing.

3.2.6 hydrophobicity: A state of low surface energy, which permits surface moisture to remain in droplets rather than sheeting or coating the elastomeric surface.

3.2.7 tracking: Irreversible deterioration of surface material from the formation of conductive carbonized paths.

3.2.8 treeing: Irreversible internal deterioration by the formation of conductive or nonconductive filamentary channels.

3.3 Mechanical terms

The following terms apply to the mechanical characteristics and ratings of the insulator.

3.3.1 apparent creep: Permanent deformation resulting from long-term performance above the damage limit.

3.3.2 application curve: A set of contour curves depicting the relationship among applied vertical, longitudinal, and transverse loads on the solid or hollow core line post insulator.

3.3.3 buckling load: The compressive load at which the core begins to deflect elastically in a direction not in line with the applied load. The loading at which this occurs is dependent on the slenderness ratio for the design.

3.3.4 cantilever breaking load (CBL): The maximum load attained during a destructive cantilever test.

3.3.5 damage limit: The load that corresponds to the maximum stress the insulator can sustain without loss of strength with time. At loads below this limit, no core fibers are broken; thus, the strength is not affected for the duration of the load application. At loads above this limit, some core fibers are broken and an apparent creep phenomenon may occur. The time to failure depends on the load.

3.3.6 deflection curve: A curve relating resultant load applied to a line post insulator with the linear displacement of the line end fitting from its unloaded position.

3.3.7 maximum design cantilever load (MDCL): A cantilever load rating assigned by the manufacturer. This load may be applied to the insulator every day with no deleterious effect on the service life. This rating is considered equivalent to the reference cantilever load (RCL).

3.3.8 reference cantilever load (RCL): The RCL is no more than 50% of the specified cantilever load (SCL).

3.3.9 specified cantilever load (SCL): A rating specified by the manufacturer that must be verified by a cantilever load test. It shall be below the CBL and is demonstrated by testing. It forms the cantilever-loading basis for selection of a composite insulator.

3.3.10 specified tensile load (STL): A tensile load specified by the manufacturer, which can be withstood by the insulator when tested under conditions prescribed by standards. It forms the tensile loading basis for selection of an insulator.

3.3.11 torsion: Deflection or twisting about the axis, which causes lines normally parallel to the axis to become helices.

3.4 Line loading terms

For the purposes of this guide, the following loading conventions will be used.

3.4.1 longitudinal loading: A force applied at the line end of the insulator, typically by the conductor, which is horizontal and parallel to the axis of the conductor.

3.4.2 vertical loading: The force applied at the line end of the line post insulator resulting from the effects of gravity and other vertical loads.

3.4.3 transverse loading: A force applied at the line end of the insulator, which is horizontal and parallel to the axis of the conductor.

3.5 Dimensional terms

The following terms apply to the physical dimensions of the insulator.

3.5.1 creepage distance: The shortest distance between metal end fittings at either end of an insulator along the surface of the sheath/housing and weathersheds. *Syn*: **leakage distance**.

3.5.2 leakage distance: *See*: **creepage distance**.

3.5.3 strike distance: The shortest distance between the conducting components of an insulator as determined by a taut string across the weathersheds plus any additional distance to the conducting components. The shortest total external distance between conductive components.

4. Elastomeric aging and long-term endurance of composite insulators

The performance of an insulator is dependent on its ability to endure the long-term mechanical and electrical stresses imposed upon it during its service life. The mechanical stresses are caused by tension, compression, bending or torsion loads, which may be static or dynamic. The electrical stresses are caused by steady state power frequency or d.c. voltages and occasional transient over voltages which may produce discharges or arcing.

A composite insulator is designed to withstand specified service stresses for the lifetime of the unit. The fiberglass core and the metallic end fittings are integral to the mechanical function while the housing (sheathing and weathersheds) provides the required electrical leakage distance and also protects the core. Both the core and the housing contain elastomers and inorganic materials. Aging of the elastomers in the insulator system may affect the insulator’s functional properties. Therefore, it is vitally important to evaluate the effects of material aging on the performance of the insulator system.

Elastomers are used in many forms, and changes in the properties of the elastomeric composition with aging may or may not be relevant to the functions and design of the insulator system. All elastomers will age under long-term exposure to sunlight, weathering, contamination, corona dry-band discharge activity and temperature. However, in the case of composite insulators, aging is only important if the material changes cause a significant reduction in the unit’s performance capability or service life.

In the valuations of the aging of composite insulators, it is necessary to analyze insulator functions and determine system failure mechanisms. This means:

a) Determine the dominant insulator failure mechanisms through a consideration of materials, processing, environment and stress on the insulator.

b) Determine which changes in material properties are likely to result in an unacceptable reduction of the insulator's in-service performance.

4.1 Mechanical aging

Exposure of the insulator to mechanical loads in excess of the RCL or damage limit may cause permanent changes in the structure and properties of the fiberglass-reinforced elastomeric core. These changes can be characterized as mechanical aging.

At loads above the damage limit on a resin bonded glass fiber composite core, a delayed stress rupture phenomenon may occur. The time to failure depends on the load. The residual strength of the composite material remains very high until the instant of failure. The long-term behavior of an insulator depends on the microscopic behavior of glass fiber and resin.

The long-term performance above the damage limit can be described as an "apparent creep" phenomenon, although the mechanisms involved are completely different from the known "creep" mechanisms found in metals. Attached to the notion of creep (permanent deformation under stress, time, and temperature) and the associated "damage" to the fiber-reinforced resin rod, there is the notion of long-term performance.

Load-time curves for different composite insulator designs subjected to different forms of loading are obtained through years of controlled tests. In fact, some units have been kept under relatively high loads for several years to plot the time load curve. The design and damage limits for an insulator type are based on these long-term endurance tests.

The long-term performance of the rod-end fitting assembly is also critically dependent on the continued protection provided by the housing. The aging of the housing must never result in direct exposure of the rod to the environment because this will change both the mechanical and electrical behavior of the rod. Accordingly, aging tests conducted to evaluate changes in mechanical behavior require testing of complete systems, including the housing, the rod-end fitting assembly, and the sealing system.

4.2 Electrical and chemical aging

Elastomeric aging under electrical stress in outdoor conditions may cause the following changes in the external housing of an insulator:

a) Oxidation and chemical reactions, which change the elastomeric surface and volume

b) Surface crazing and cracking due to the effects of radiation, temperature, ozone, and water

c) Erosion or tracking caused by surface discharge activity

The voltage distribution along an elastomeric insulator exposed to wet polluted conditions is dependent on the insulator surface conductance. Therefore, changes in the surface resistance can be related to the voltage withstand capability of the insulator. Changes in the chemical composition and structure of the surface of the housing materials may affect the surface resistance of insulators under wet and polluted conditions. This has been demonstrated by service experience and testing, which have shown that variations in these surface properties of the housing affect the leakage currents and withstand voltage capabilities of insulators.

Material studies have shown that the surfaces of elastomers are relatively mobile in comparison with ceramic and glass. Elastomeric molecules have much greater freedom for rearranging in the bulk or at the surface. This ability varies dramatically between different elastomers and within generic elastomeric systems. Some elastomeric surfaces have the ability to interact with pollutants and reduce the conductance of the pollution layer. This has a significant effect on the contamination behavior of composite insulators.

Long-term characteristics are established by service experience. Multistress or accelerated aging tests can be helpful, but they must be interpreted cautiously. Laboratory accelerated aging tests are conducted with the insulator or model under electrical and/or mechanical stresses and subjected to one or more of the following environmental conditions:

- Simulated solar radiation
- Artificial rain
- Dry heat
- Damp heat (near saturation)
- High humidity at room temperature (saturation must be obtained)
- Pollution

The condition of the test samples is monitored by leakage current measurements and by periodic withstand tests to establish changes in the performance capability of the insulator system under test. For more information, see Hall [B11].

4.3 Insulator design

The design and application of composite insulators in transmission and distribution systems must be based on long-term performance and endurance data and/or experience. Since there are no present standards for such evaluation, the manufacturer and the user must work together in the reliability assessment of the insulator design.

4.3.1 Core

The core (solid or hollow) should be suitable for electrical application and free of cracks, voids, moisture, and other defects that may adversely affect the insulator.

4.3.2 Weathersheds

The insulator weathersheds are made of elastomeric materials. These materials may be compounded with inorganic fillers and compounding agents as necessary to obtain the desired insulating characteristics. The specific shapes and spacing of weathersheds are not a part of this guide. These will vary by design.

4.3.3 End fittings

The insulator manufacturer normally has a variety of conductor attachments and mounting bases available. Insulator end fittings may be composed of hot-dip galvanized ferrous or nonferrous metals. The end fitting must be resistant to arc damage.

5. General criteria

5.1 Drawings

Manufacturer's drawings should show the outline of the insulators, together with all pertinent dimensions to include section length, leakage distance, strike distance, number and diameter of weathersheds, weathershed spacing, details of the end fittings, corona rings, and the base upsweep angle.

5.2 Design tests

For design tests, see ANSI C29.11-1989, CEA LWIWG-02 [B4],and IEC 61109.[7]

5.3 Contamination

In laboratory tests and field installations, composite insulators have been shown to exhibit short-term resistance to contamination flashover that is superior to that of conventional ceramic or glass insulators. This is primarily attributed to the significant difference in the geometry and wet surface resistance of elastomeric and ceramic insulators. However, the contamination flashover performance of composite insulators deteriorates to some degree with surface aging. This surface aging can be accelerated by exposure to different environmental conditions. The extent of this aging and its effect on the insulator's contamination flashover performance is thought to be dependent on the shed material and design used, as various designs and materials exhibit a different ability to maintain and/or recover their original high surface resistance under long-term service conditions.

Although composite insulators have resolved numerous contamination flashover problems, in very severe environments, excessive deposits of contaminants may cause localized activity leading to damage on composite insulators. Before using composite insulators in locations where the insulators may be totally engulfed by contaminants, prior performance of similar composite insulators in comparable environments should be reviewed. When composite insulators are installed in severe environments, a periodic inspection program is advised to ensure that the insulators remain in good condition. As composite insulators may retain more contaminants than their ceramic or glass counterparts, the aim of such an inspection program should be to detect actual damage to the insulators rather than the levels of contamination. Typically the heavy contamination may cause localized activity resulting in discoloration, surface erosion, cutting, or puncture of weathershed material.

5.4 Leakage distance requirements

At the time this guide was prepared, composite insulators had commonly been applied with leakage distances equal to or greater than those provided in the past for ceramic units. As in some cases, composite insulators appear to have better flashover resistance than ceramic units having the same leakage distance, clean environmental conditions may allow composite insulators to provide equivalent contamination flashover resistance performance with slightly less leakage distance than traditional ceramic insulators. Caution is recommended when choosing or specifying leakage distance.

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[7] Information on references can be found in Clause 2.

The margin by which composite insulator contamination flashover performance differs from that of ceramic is dependent on the design of the insulator and on the material from which the insulator housing is composed. Materials having long-term *hydrophobicity* provide a larger margin than those that do not. Conclusive data describing long-term experience with reduced leakage composite insulators are currently not available. Although practice indicates that reduced leakage composite insulators can be successfully used in areas that are clean or characterized by light levels of contamination, there is concern that use of reduced leakage insulators in heavily contaminated areas may result in increased leakage current and dry band arcing, thereby shortening the insulators' service life.

For specific leakage recommendations, refer to IEC/TR 60815 and EPRI's Transmission Line Reference Book [B7].

5.5 Temperature limits

Composite insulators are in service in the hottest and coldest of climates with no unusual effects due to temperature extremes. Manufacturers have generally agreed to a continuous ambient operating range of –50 °C to +50 °C.

5.6 Chemical environments

A variety of different materials are used in the various types of composite insulators. In some special applications (such as diesel railways), these materials may be affected by hydrocarbon vapors or other chemicals. Potential effects involve those on the elastomeric material itself and those relating to the surface conditions on the elastomer. The chemical resistance of materials vary according to the structure of the elastomer and the chemical pollutant involved. Continuous exposure to hydrocarbon solvents may attack the elastomer or cause certain weathershed materials to experience swelling or embrittlement. Damage to insulator weathersheds has occurred when insulators have been left in contact with wood poles treated with preservatives. Certain chemical pollutants sometimes found in cooling tower mists may act as a surfactant film or *surface active agent* over the weathershed material that can affect the hydrophobicity of some elastomeric materials. An inspection program should be put into place when any type insulator is applied in chemical environments. Insulator manufacturers should be consulted for specific recommendations.

5.7 Power arc damage

When a high-current fault is struck across the ends of an insulator, the mechanical integrity of the insulator may be adversely affected by heating and erosion of the metal end fitting to which the arc roots attach. The degree of damage to the end fittings depends on the insulator design and materials coupled with the magnitude and duration of the current. In some instances, metal grading rings capable of withstanding a power arc can provide additional protection to the insulator end fittings from power arc damage. Such grading rings must be appropriately designed and properly attached to the insulator end fittings. Comparative tests and designs are referenced in Beausejour [B1]. Possible scenarios that will result in eventual damage to the insulator after the occurrence of a power arc include rod exposure at the metal end fitting and/or corona damage from corona generated at metal surfaces that have been damaged during the power arc.

5.8 Service experience of composite line post insulators

Polymer insulators were first introduced in the 1960s in the United States. They were used primarily on distribution lines, but they did not perform well in service, with these early designs suffering from tracking and ultraviolet degradation. Application of polymeric line post insulators on transmission lines was initiated in the 1970s as the technology developed with the introduction of new designs, materials, and methods of end-fitting attachment. Experience with these more current designs is considerably better than with their first-generation predecessors. Today, composite line post insulators are considered reliable and are often specified over other insulators.

Although composite line posts are used in both transmission and distribution systems, the majority have been applied on distribution systems. However, there has been little specific documentation of distribution class service experience. Service experience with transmission class composite line post insulators has been summarized as a part of two surveys. These surveys were conducted by CIGRE and EPRI, and both organizations reported on experience with the use of composite suspension, tension, and line post insulators on ac systems. Both were published in 1989. The conclusions of these surveys with regard to line post applications are summarized in this subclause. It should be noted that this information is dated; however, it represents the only currently available comprehensive base of information.

The EPRI survey indicated that in the United States, composite insulators including suspension, tension, and line post units are used over a wide range of voltages. They are applied to different structures and over the entire spectrum of contamination levels. Overall the operational experience was considered good in 78% of applications, acceptable in 18%, and poor in 4%. Of the failures reported, some 17% were identified as electrical, a similar number as mechanical. Over 60% of the reported failures were classified as general deterioration, some 2% were a consequence of gunshot, and the remaining 2% were not identified. The electrical failures included flashover due to surface contamination, bird droppings, salt spray, and icing. The reported mechanical failures included rod damage due to excessive torsional loading encountered during handling and installation and several occurrences of brittle fracture.

The CIGRE survey included data from the EPRI survey wherever possible. It indicated that its data covered approximately 50% of the transmission class insulators manufactured up to 1986, and that most of the insulators used worldwide were installed in North America. The survey results indicated that in 1987 there were approximately 36,000 composite line posts installed worldwide. Some 28,400 of these were used on systems below 200 kV. Applications in the range of 200 kV and up, but less than 300 kV, accounted for 7300 of the installed units. Applications in the range of 300 kV and up, but less than 500 kV, included 380 of the installed units, and there were only 22 line post applications at system voltages of 500 kV and above. The report also presents details on special applications of composite insulators from the viewpoint of what proportions are installed under what type of operating environments, as well as failure statistics and descriptions. The report contains the following conclusions. With regard to composite insulators as a whole, including suspension, tension, and line post units, most of the reported failures involved insulators that were produced in the early 1980s or before. Since that time, many manufacturers have modified and improved the design and production quality control of their insulators. Users may also have modified their criteria for the utilization of composite insulators. With regard to line posts in particular, there were 25 failures reported on systems operating below 200 kV, no failures on systems rated between 200 kV and 300 kV, and 4 failures on systems operating in the 300 kV to 500 kV range. Of the total 29 line post failures reported, 26 were attributed to weathershed failures and 3 were due to weathershed/rod interface problems. When the definitions of a failure in the CIGRE and EPRI surveys are harmonized, the number of failures (i.e., the operational experience quoted in the preceding paragraph) agrees with the EPRI results. It further concludes that in North America, the production and therefore presumably the use of composite insulators has very much increased since the survey was carried out.

Detailed information on the results of these surveys can be found in “Worldwide Service Experience with HV Composite Insulators” [B25] and Schneider et al. [B21].

6. Mechanical considerations for line post insulators

6.1 Mechanical rating criterion

The load ratings applied to composite line post insulators are usually single load maxima. Load ratings are supplied by the manufacturer and should be applied as intended for normal line loading. For combined loads, refer to 6.3.

6.1.1 Cantilever

ANSI C29.17 defines SCL and CBL.

Manufacturer's are required to include the SCL in pounds or thousands of pounds (K) in the marking for the insulator.

NOTE—Reference 3.3, 6.1.1, and 7.1 for SCL.

6.1.2 Tension loads

Tensile strength of composite line post insulators is dependent on the mechanical characteristics of the end fittings and on those of the core-to-end fitting interfaces. This rating is typically given as the specified tensile load of the insulator.

6.1.3 Compression loads

Compression loads on line post insulators do not usually result in damaging strains until severe buckling occurs, resulting in permanent damage.

Generally, elastic deformation of long line posts, although not desirable, is not damaging. For further information on this, the manufacturer should be consulted.

6.1.4 Torsion loads

At the writing of this guide, torsional ratings have not been established. Extreme torsional loads may cause cracking of the fiberglass rod or end-fitting rotation about the rod. End-fitting failure may also result. The manufacturer should be consulted to determine the torsional capability of a given design.

6.2 Deflection

Due to the elastic nature of the components of composite line posts, applied moments will cause deflection of the insulator. Under differential span loading, the ability to deflect may enable the post to equalize the span tensions without experiencing the full magnitude of the imbalance. There have been numerous reports of broken conductor line load imbalances that have been absorbed by longitudinal deflection of multiple line posts, containing cascading failures. If the damage limit of the post is exceeded, permanent deformation of the base or line post may occur, indicating that the post assembly should be replaced.

Under transverse loading, deflection of the post may result in changes in the overall moment in the core as a result of the offset. The adjustment is approximately equal to the deflection multiplied by the transverse loading. Transverse compression loading will increase the moment experienced by the core, whereas transverse tension loading will reduce the moment. A line post application curve can be obtained from the manufacturer to detail the adjustments in the loading capabilities as a result of these transverse loads. Specifically, the manufacturers should provide deflection values associated with the RCL of the insulators.

6.3 Combined loads

Actual line loads are rarely single loads. Usually, they are a combination of loads. When comparing actual mechanical load conditions with composite line post mechanical strength ratings, it must be recognized that vertical transverse and longitudinal loads each contribute to the total bending moment on the insulator and, therefore, to total cantilever load.

To aid designers in determining how the combined mechanical loads in an intended application compare with the cantilever strength capability of a particular composite line post insulator, manufacturers ***should*** provide application curves and instruction on their proper use, along with supporting calculations and directional load limitations in order for the line designer to accurately evaluate the application of the insulator for exact usage. These curves are based on the manufacturer’s recommended loads.

7. Interchangeability of insulators

In this guide, interchangeability refers to the ability to interchange standard ceramic with composite insulators. Several aspects of interchangeability need to be considered, namely, mechanical strength, deflection, electrical performance, mounting configuration, and section length. For additional information on insulators of the distribution class, see Beausejour [B1].

7.1 Mechanical strength

Composite post insulators are available in cantilever strengths lower than, equal to, or exceeding those of their ceramic counterparts. They are normally interchangeable, but it is recommended that caution be used due to differences in rating systems. Per ANSI standards, the cantilever rating of ceramic posts is determined by the average value obtained during an ultimate cantilever strength test. Consequently, published cantilever ratings for ceramic posts are ultimate values. The NESC recommends that the maximum cantilever working load be limited to 40% of ultimate.

Historically, the methodology employed to determine cantilever ratings for composite line posts varied from manufacturer to manufacturer. ANSI C29.17 now defines an SCL rating that is below the ultimate strength CBL determined as the maximum load reached during the test.

The manufacturers recommended working load, sometimes called the MDCL or RCL, and which maybe as much as 50% of the SCL, is usually marked on the insulator.

The acceptance of the method described in ANSI C29.17 is recommended for the future use.

7.2 Electrical

There are no electrical interchangeability problems with ceramic that are known at this time. For contamination performance, refer to 5.3.

7.3 Section length (spacing)

Small changes in section length are usually not critical for line post insulator applications. Therefore, it is common practice to adjust the line post section length to obtain the proper cantilever strength and electrical characteristics for direct interchangeability with ceramic line posts.

8. Grading devices

Grading devices are used to reshape the electric field at the insulator ends. They reduce the electrical stress in the bulk and on the surface of the insulator, and in the surrounding air. Grading devices normally take the form of metal rings, which are designed to prevent corona on the insulator assembly under fair weather conditions. Corona can be the source of several problems detrimental to the performance of the insulators and to the insulators themselves. Corona on composite insulators results in the generation of radio noise, and it can cause deterioration of the insulating material itself. Presence of corona can result in corona cutting and deterioration or loss of composite insulating materials.

Compaction of lines may make the use of corona rings on composite insulators necessary. In areas of heavy contamination, corona rings may be necessary for insulators that normally do not require them, and larger rings may be needed for those insulators that do usually require rings. Grading devices are normally required on post insulators above 230 kV. A grading device may be required on the tie-back suspension insulator of both horizontal vee and braced post assemblies operating at 230 kV and above. A single grading ring shielding both the post and the tie-back insulator may be used.

9. Maintenance

9.1 Insulator cleaning

IEEE Std 957 addresses washing of nonceramic transmission class insulators. The procedure recommended in IEEE Std 957 shall be followed for post type insulators. The main points of the recommended procedure are as defined in 9.1.1–9.1.3.

9.1.1 Insulator pressure washing

The insulators can be washed with high-pressure, medium-pressure, and low-pressure water depending on the bonding used for the weathersheds. The water stream can be directed in any angle if the weathersheds are directly molded or the individual weathersheds are bonded to a polymer sheath or to each other. If the weathersheds are unbonded, the water stream shall be directed to the upper surface of the weathershed.

The frequency of the washing is significantly less than required for porcelain insulators. The manufacturer shall be consulted for the selection of the most appropriate cleaning method.

9.1.2 Hand washing

The deenergized insulators can be hand washed using mild detergent. After washing, the insulators shall be rinsed by low-pressure water.

9.1.3 Compressed air with dry abrasive cleaning

The insulator is cleaned by compressed air-driven dry abrasive media, like ground corn cob mixed with ground walnut shells or ground porcelain. The cleaning efficiency may be increased by mixing powdered silica or lime with the dry media. After cleaning, high-pressure clean air is used to remove residuals from the insulator surface. This technique is not recommended for silicone rubber weathersheds, because this method temporarily destroys the hydrophobicity of the silicone rubber.

9.2 Greasing

Experience has shown that channeled arcing may lead to tracking on a composite insulator that has had grease applied to its housing/weathershed surfaces. Therefore, greasing of composite insulators is not advisable.

9.3 Damaged insulators

Damage to composite line post insulators must be determined subjectively. As a general rule, if the core is exposed to the elements, the insulator should be replaced. Problems that can result in exposure of the core include power arc damage, hardware/housing seal damage, tracking and erosion damage of the elastomer, and gunshot damage.

Power arc damage can expose the core by either removing sufficient material from the end fittings or by resulting in a split in the elastomer usually immediately adjacent to the end fittings. In either case, the insulator should be replaced at the earliest opportunity.

Hardware/housing seal damage usually occurs as a result of improper handling. This break in the seal may result in moisture entering through the gap into the core.

Tracking and/or erosion damage of the elastomer is usually visually apparent. These types of problems normally occur only in highly contaminated environments. If it is suspected that the core is exposed, the insulator should be replaced.

Gunshot damage may occur on either the weathershed portion or the core of the line post insulator. Small holes or embedded material in the outer sections of the weathersheds should not be cause for concern. The electrical effects will usually be minimal, unless the damage is extreme. Holes or embedded material in the core of the line post should be considered cause for replacement of the insulator.

10. Handling

Composite insulators have different physical dimensions and characteristics from their ceramic counterparts. A direct consequence of this is that the handling requirements for composite insulators are different from those routinely used for ceramic units. This clause describes in general terms those handling requirements.

10.1 Packaging

Composite insulators will normally be bulk packed in a wood or corrugated cardboard carton. The number of units per pack will usually be determined by the size of the units or order size. Insulators may also be individually packed within the pack in tubes or sleeves. The actual packing method is usually determined by the manufacturer; thus, special requirements should be discussed.

10.2 Removal from packing

Composite insulators have an elastomeric housing. Therefore, any means of removal from the packaging that involves cutting of packing materials should be done in such a manner that the elastomeric housing of the insulator is not cut. Care must be taken, and each insulator should be inspected for damage after being removed from the packing material.

10.3 Handling, transportation, and installation

Composite insulators are much lighter than the corresponding ceramic or post insulators. This makes them much easier to transport and install. They can be torn by sharp objects or tools, and they can be damaged when transported unprotected on the overhead racks of crew trucks. A single cut or tear that exposes the fiberglass rod to moisture may eventually result in the mechanical failure of the insulator. During line construction when ground assembly is used, caution should be taken to ensure that the insulator will not be subjected to compressive or bending loads during structure erection. Construction methods that subject a composite insulator to a force or load that it would not see in service should not be used.

Listed below are some guidelines to be applied in the handling, transporting, and installing of composite insulators. Procedures that should be followed to ensure that composite insulators are not damaged during handling, transportation, and installation are as follows:

a) General care should be taken in handling.

b) Insulators should be stored and transported in their shipping crates.

c) Units should be carried or lifted by their end fittings.

d) Insulators should be thoroughly inspected for cuts or abrasions before installation.

The following list contains cautions against specific work practices that may result in damage to composite insulators:

- Insulators should not be stacked on one another (the end fitting of one can cut into the elastomeric housing of another).
- Insulators should not be lifted by the elastomeric sheds unless carefully done by hand. Slings should never be placed over the sheds.
- Insulators should not be subject to any excessive bending.
- Insulators should not be stepped on or walked on.
- Insulators should not be climbed on after installation.
- Insulators should not be dropped.

10.4 Storage/warehousing

When insulators are stored, care should be taken to avoid resting them directly on the weathersheds. This may result in the weathersheds taking a set and remaining in the deformed position when installed. This deformation is a cosmetic problem only.

Care should also be taken to store insulators above the ground. The abrasive quality of the alumina trihydrate is attractive to rodents as a means for grinding down their teeth. This phenomenon has been reported with mice, rats, and beavers.

In ground storage conditions in humid environments, the growth of fungi on the surface of the elastomer has also been reported. Although most elastomers are fungistatic, fungi will adhere to the surface. Some utilities have reported success in removing the fungi by using a dilute solution of chlorine bleach.

Annex A

(informative)

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