# Composite Station Post Insulators Maintenance, Diagnosis and Repair Guide

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# 1 General Provisions

## 1.1 Purpose

This guide is intended to regulate the maintenance, defect diagnosis and repair/replacement of composite station post insulators during operation; to clarify the work requirements and criteria for inspection, maintenance, testing, condition assessment, defect disposal and replacement; to detect and eliminate equipment defects in a timely manner; to prevent equipment damage or grid accidents caused by failures of composite station post insulators; and to ensure the safe and reliable operation of equipment in substations and converter stations.

## 1.2 Scope of Application

This guide applies to station post insulators with a nominal voltage higher than 1000 V, covering composite station post insulators used in electrical installations or equipment in a.c. systems (1000 V and above) and d.c. systems (±1500 V and above).

# 2 Structural Composition and Main Failure Modes of Composite Station Post Insulators

## 2.1 Structural Composition

A composite station post insulator is composed of three main parts: the core rod, the weather shed (housing) and the end fittings. Its external insulation performance is mainly provided by the silicone rubber weather shed, and its mechanical load-bearing capacity is mainly borne by the core rod.

(1) Core rod: made of epoxy resin-impregnated glass fiber, it bears mechanical loads such as tension and bending, and is the key component that determines the mechanical strength of the insulator.

(2) Weather shed (housing): made of high-temperature vulcanized (HTV) silicone rubber, it wraps around the core rod to form the housing and extends outward to form sheds so as to increase the creepage distance. Silicone rubber has excellent hydrophobicity and hydrophobicity transfer, which can significantly reduce the risk of pollution flashover.

(3) End fittings: generally made of metal such as cast iron or steel, they are fixed to the ends of the core rod by crimping, adhesive bonding or mechanical connection, and are used to connect with busbars, conductors or equipment and to transmit mechanical loads. The connection parts are provided with sealing structures to prevent the ingress of moisture.

## 2.2 Main Failure Modes and Mechanisms

The failure modes that composite station post insulators may exhibit during long-term service mainly include the following categories, and their mechanisms should be the key concern of maintenance and diagnosis.

**Table 2-1 Main failure modes of composite station post insulators**

| Failure mode | Mechanism and hazard |
|---|---|
| Core rod brittle fracture | Moisture ingress into the core rod, combined with the combined action of the electric field and mechanical stress, causes stress corrosion and brittle fracture of the glass fibers, often without obvious warning signs, and is the most hazardous. |
| Slippage or detachment of end fittings | Poor crimping, overloading or material fatigue leads to relative displacement or separation between the end metal fittings and the core rod, affecting the reliability of the mechanical connection. |
| Seal failure and water ingress | Ageing, damage or failure of the end sealing or sealing compound allows moisture to penetrate along the interface between the core rod and the housing, inducing internal discharge and core rod deterioration. |
| Shed cracking and ageing | Ultraviolet radiation, temperature, discharge and other effects cause the silicone rubber to age, embrittle, powder and crack, reducing the external insulation and hydrophobicity performance. |

| | |
|---|---|
| Decrease or loss of hydrophobicity | Contamination, chemical attack, discharge and other factors cause the hydrophobicity of the silicone rubber surface to decrease or be permanently lost, increasing the risk of pollution flashover. |
| Tracking and erosion | Local discharge occurs under the combined action of surface pollution/moisture and the electric field, forming carbonised paths or erosion perforation, which may lead to insulation failure. |
| Interface breakdown | Discharge breakdown occurs along the interface between the core rod and the housing under the action of the electric field due to moisture ingress or the presence of defects. |
| Corrosion of metal parts | Electrochemical corrosion of the end fittings occurs in polluted and humid environments, affecting the mechanical strength and connection reliability. |

# 3 Maintenance

## 3.1 Classification and Cycle of Maintenance

The maintenance of composite station post insulators is classified, by nature and cycle, into routine inspection and periodic maintenance. The maintenance cycle shall be determined taking into account the equipment voltage level, operating environment, degree of contamination, operating experience and condition assessment results, and shall comply with the requirements of DL/T 2439.2—2024 and the equipment operation regulations.

**Table 3-1 Classification and cycle of maintenance**

| Maintenance category | Cycle | Main content |
|---|---|---|
| Routine inspection | Carried out simultaneously with routine patrols | Direct visual checks of appearance, discharge, abnormal noise, tilting, loosening, etc. |
| Periodic maintenance | According to the maintenance cycle (generally once a year or per regulations) | Outage cleaning, tightening inspection, hydrophobicity testing, electrical tests, etc. |

## 3.2 Inspection Items and Methods

Inspection is the main means of detecting early defects of composite station post insulators. The main items include:

(1) Visual inspection: check whether the housing and sheds show cracking, damage, powdering, deformation or sagging, and whether the shed surface shows discharge traces, erosion, tracking or erosion marks;

(2) Surface discharge inspection: under humid, polluted or night-time conditions, observe whether the shed surface shows corona, partial discharge or flashover phenomena; where necessary, carry out live-line testing in combination with a UV imager;

(3) Tilting and mechanical state check: check whether the insulator is tilted, whether the end fittings show signs of loosening, displacement or slippage, and whether the connecting fittings are tightened and free from corrosion;

(4) Abnormal noise and abnormal odor check: listen for abnormal discharge noise and detect any abnormal odor; further live-line testing is required in the event of abnormalities;

(5) Seal and end fitting check: check whether the sealing at the connection between the end fittings and the core rod is intact, and whether there are signs of cracks, water ingress or leakage.

## 3.3 Routine Outage Maintenance Items

Routine outage maintenance shall be carried out under conditions that ensure safety. The main items include:

(1) Outage cleaning: clean the surface of the housing to remove contaminants, dust, bird droppings and other adhered matter so as to prevent pollution flashover;

(2) Tightening and mechanical check: inspect and tighten the end fittings and connecting fittings, and verify the reliability of the mechanical connection;

(3) Hydrophobicity testing: carry out classified testing of the hydrophobicity of the housing surface in accordance with GB/T 22079—2019 and DL/T 2439.2—2024, and assess changes in hydrophobicity performance;

(4) Seal check: check whether the end sealing structure is aged or cracked;

(5) Electrical tests: as required, carry out tests such as insulation resistance, leakage current or power-frequency withstand voltage to judge the insulation condition.

## 3.4 Maintenance Records and Archives

Records shall be made for each maintenance operation, including the maintenance time, personnel, maintenance items, problems found, disposal measures and results. Maintenance records shall be archived in a timely manner and serve as the basis for equipment condition assessment and maintenance decisions. The record forms are given in Appendix A.

# 4 Diagnosis

## 4.1 Live-line Testing

Live-line testing can promptly detect insulator abnormalities without interrupting power supply, and is an important technical means of condition-based maintenance. It mainly includes the following methods:

**Table 4-1 Live-line testing methods**

| Testing method | Object of detection | Main function |
|---|---|---|
| UV imaging detection | Detects the ultraviolet radiation generated by corona and partial discharge | Detects surface discharge, corona and signs of discharge development |
| Infrared temperature measurement | Detects the temperature rise on the insulator surface | Detects abnormal temperature rise caused by partial discharge and internal defects |

Live-line testing shall be carried out on the premise of satisfying the safety distance requirements, and the test results shall be comprehensively analysed in

combination with the equipment operating conditions and environmental conditions. When signs such as discharge or abnormal temperature rise are found, the testing cycle shall be shortened and the insulator shall be placed under condition tracking.

## 4.2 Outage Testing and Tests

Outage testing and tests are carried out when the equipment is de-energised, and are used to make a determination on the insulation condition and mechanical state of the insulator. They mainly include:

(1) Insulation resistance measurement: measure the overall insulation resistance of the insulator to assess its insulation condition;

(2) Leakage current measurement: apply a test voltage and measure the surface leakage current to assess the contamination and moisture condition;

(3) Power-frequency withstand voltage test: apply the specified power-frequency voltage to the insulator to verify its withstand capability; the test voltage and criteria shall be executed in accordance with DL/T 1048—2021 and the relevant provisions;

(4) Hydrophobicity classification testing: determine the hydrophobicity class of the housing surface by the methods specified in GB/T 22079—2019;

(5) Visual and seal inspection: carry out a detailed inspection of the housing, sheds, end fittings and sealing structures and record the results.

## 4.3 Laboratory Diagnosis

For insulators whose condition is difficult to determine by outage tests or where internal defects are suspected, samples may be taken and sent to a laboratory for special diagnosis, including core rod material analysis and strength tests, ageing analysis of the housing material, inspection of the core rod–housing interface, scanning electron microscope (SEM) analysis, and hydrophobicity recovery characteristic tests. The results of laboratory diagnosis serve as an important basis for defect determination and replacement decisions.

## 4.4 Condition Assessment and Classification

The condition of composite station post insulators shall be assessed by integrating inspection, live-line testing, outage testing and operating history information, and shall be classified into four grades according to the severity of the defect:

**Table 4-2 Condition assessment and graded disposal**

| Condition grade | Main criteria | Disposal principle |
|---|---|---|
| Normal | Sound appearance, normal hydrophobicity, no abnormal test results | Carry out maintenance and testing at the normal cycle |
| Attention | Minor defects present (e.g. light contamination, decreased hydrophobicity) | Strengthen monitoring, shorten the testing cycle, and dispose of in due course |
| Abnormal | Obvious defects present (e.g. shed cracking, loosened end fittings, signs of discharge) | Arrange outage inspection and disposal within a specified time limit |
| Severe (hazardous) | Defects present that endanger safe operation (e.g. signs of core rod brittle fracture, seal failure with water ingress, permanent loss of hydrophobicity) | Immediately de-energise, isolate and replace |

## 4.5 Diagnosis Records and Reports

The diagnosis results shall be compiled into a test report, including the equipment information, testing methods, test data, criteria, defect analysis and assessment conclusions, and handling recommendations. The test report shall be archived in a timely manner and serve as the basis for condition assessment and maintenance decisions.

# 5 Repair and Replacement

## 5.1 Field-repairable Defects and Procedures

Defects found during operation that do not affect the structural integrity and mechanical strength of the insulator may be handled by field repair. The main measures include:

(1) Contamination cleaning: remove contamination from the housing surface to restore external insulation performance;

(2) Fitting tightening: tighten the loosened or displaced end fittings and connecting fittings to restore connection reliability;

A work plan shall be prepared for field repair to ensure that the repair procedures meet the corresponding technical requirements; after repair, a visual inspection and necessary verification tests shall be carried out.

## 5.2 Non-repairable Defects and Replacement Criteria

A composite station post insulator shall be replaced in any of the following circumstances:

(1) The hydrophobicity of the entire insulator is lost and cannot be restored;

(2) The housing or the roots of the sheds are damaged or cracked, or there is damage affecting external insulation such as tracking or erosion;

(3) Seal failure, cracking, slippage or relative displacement occurs at the connection between the end fittings and the core rod;

(4) The core rod shows signs of brittle fracture, water ingress at the interface, or suspected internal insulation damage;

(5) The insulation performance or mechanical performance is determined by testing not to meet the operating requirements.

The decision to replace shall be determined comprehensively by taking into account the equipment voltage level, operating environment, defect severity and risk

assessment; where necessary, the manufacturer or a professional testing organisation shall be consulted.

## 5.3 Replacement Work Procedure and Installation

The replacement of a composite station post insulator shall be carried out after the equipment is de-energised and safety measures are taken. The general procedure is as follows:

(1) Apply for an outage work permit and complete safety measures such as isolation, earthing and voltage verification;

(2) Disconnect the ends of the insulator from the busbar or equipment, remove the old insulator, and record the original installation position, angle and connection method;

(3) Carry out a receiving inspection of the new insulator, and verify the specification, type, factory test report and visual condition;

(4) Install the new insulator in accordance with the manufacturer’s requirements and the specified torque, ensuring a reliable end connection and uniform load distribution;

(5) After installation, carry out a visual inspection, verticality verification and necessary electrical tests;

(6) Complete the acceptance before restoring power supply, and update the equipment ledger.

## 5.4 Return-to-factory Handling and Scrapping

For insulators whose cause needs further analysis or whose defects are disputed, they may be returned to the factory or sent to a professional organisation for testing and handling. Insulators determined to be scrapped shall be scrapped through the procedures in accordance with the relevant management regulations; scrapped insulators shall be properly disposed of to prevent misuse.

### 5.5 Post-repair Acceptance and Evaluation

After repair or replacement is completed, acceptance shall be carried out in accordance with DL/T 2439.2—2024 and the relevant regulations. The acceptance includes the visual condition, installation quality, connection reliability and necessary test results. The insulator may be put into service only after passing acceptance, and the maintenance archives shall be updated.

## 6 Storage, Transportation and Receiving Inspection

### 6.1 Storage Requirements

Composite station post insulators shall be stored in a well-ventilated, dry, sun-protected place free from corrosive gases and chemicals, avoiding direct sunlight and prolonged high temperature, and away from heat sources and strong electric fields. The insulators shall be stored upright or laid flat with supporting pads in accordance with the manufacturer’s requirements, to prevent deformation under compression. During storage, the appearance shall be inspected regularly to prevent ageing and soiling of the housing and corrosion of the metal parts.

### 6.2 Transportation Requirements

Special packaging shall be used during transportation to prevent collision, crushing, rolling and tipping over. Loading and unloading shall be handled with care, and throwing or dragging is strictly prohibited. During transportation, the insulators shall be prevented from colliding with each other so as to avoid damage to the housing and end fittings, and from becoming damp or incurring water ingress. After arrival, the integrity of the packaging and the condition of the equipment shall be checked promptly.

## 6.3 Receiving Inspection

Receiving inspection shall verify that the specification, type and quantity of the insulators are consistent with the contract requirements, check that the product certificate of conformity, factory test report, technical documents and other materials are complete, and check that the appearance is free from defects such as cracks, damage, deformation and soiling. The receiving inspection records shall be archived in a timely manner.

# 7 Records and Archives Management

## 7.1 Ledger Management

An equipment ledger for composite station post insulators shall be established, recording the installation location, specification and type, manufacturer, factory serial number, commissioning date, key technical parameters, and all previous maintenance, testing, repair and replacement records, so as to realise whole-life-cycle management of the equipment.

## 7.2 Record Forms

Uniform record forms shall be used for maintenance, testing, diagnosis and replacement work, and the operation time, personnel, items, data, problems found and disposal results shall be fully recorded. The commonly used record forms are given in Appendix A.

## 7.3 Archive Requirements

The equipment archives shall include the product technical documentation, factory test reports, receiving inspection records, all previous maintenance and testing records, diagnosis reports, defect and replacement records, etc. The archives shall be stored on a long-term basis, managed centrally and easy to query, and shall serve as the basis for equipment condition assessment and maintenance decisions.

# Appendix A Maintenance and Testing Record Forms

This appendix provides the commonly used record forms for the maintenance and testing of composite station post insulators, for use by the respective user organizations with adjustments according to actual conditions.

**Table A-1 Inspection record form for composite station post insulators**

| Inspection item | Check content | Inspection result | Problem found | Handling measure | Remarks |
|---|---|---|---|---|---|
| Appearance | Cracking, damage, powdering, deformation of housing/sheds | | | | |
| Discharge | Surface discharge, corona, discharge traces | | | | |
| Mechanical state | Tilting, loosened end fittings, slippage, corrosion | | | | |
| Sealing | Cracking, water ingress, leakage of end sealing | | | | |
| Abnormal noise/odour | Discharge noise, abnormal odour | | | | |
| Others | Contamination, bird damage, adhesion of foreign matter | | | | |

**Table A-2 Outage testing record form for composite station post insulators**

| Test item | Test condition/ method | Test data | Criterion/reference value | Determination result | Remarks |
|---|---|---|---|---|---|
| Insulation resistance | | | | | |
| Leakage current | | | | | |
| Power-frequency withstand voltage | | | | | |
| Hydrophobicity classification | | | | | |
| Visual/seal inspection | | | | | |

**Table A-3 Defect and disposal ledger for composite station post insulators**

| Equipment No. | Defect discovery time | Defect description | Defect grade | Disposal method | Disposal time | Disposal result |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |

## Appendix B Common Defects and Disposal Cross-reference Table

Table B provides the cross-reference between the common defects of composite station post insulators and the recommended disposal methods, for reference in field judgement. The specific disposal shall be determined in combination with the actual condition of the equipment and the corresponding regulations.

**Table B Cross-reference table of common defects and disposal**

| Common defect | Main hazard | Recommended disposal | Condition grade |
|---|---|---|---|
| Surface contamination/dust | Increased risk of pollution flashover | Clean; apply anti-pollution-flashover coating where necessary | Attention |
| Decreased hydrophobicity | Reduced anti-pollution-flashover performance | Test and classify; apply RTV/PRTV coating; strengthen monitoring | Attention/Abnormal |
| Shed cracking/damage | Impaired external insulation performance | Assess the degree of damage; replace if severe | Abnormal/Severe |
| Tracking/erosion | Risk of insulation failure | Carry out outage inspection; replace if severe | Abnormal/Severe |
| Loosened/slipped end fittings | Reduced reliability of the mechanical connection | Tighten; replace if it cannot be restored | Abnormal/Severe |
| Seal failure with water ingress | Risk of core rod deterioration/brittle fracture | Re-seal; replace where necessary | Severe |
| Signs of core rod brittle fracture | Possible sudden fracture | Immediately de-energise, isolate and replace | Severe |

| | | | |
|---|---|---|---|
| Permanent loss of hydrophobicity | Loss of anti-pollution-flashover capability | Replace | Severe |

## Appendix C List of Referenced Standards

The list of the main referenced standards involved in this guide is given in Table C-1. The currently effective version of each standard shall prevail as officially published.

**Table C-1 List of referenced standards**

| Standard number | Standard title |
|---|---|
| DL/T 2439.2—2024 | Application Guide for Station Post Insulators for Nominal Voltage Higher than 1000 V — Part 2: Composite Station Post Insulators |
| DL/T 1048—2021 | Composite Station Post Insulators for Power Systems — Definitions, Test Methods and Acceptance Criteria |
| GB/T 22079—2019 | Polymeric HV insulators for indoor and outdoor use — General definitions, test methods and acceptance criteria |
| IEC 62217:2012 | Polymeric HV insulators for indoor and outdoor use — General definitions, test methods and acceptance criteria |
| GB/T 19519—2014 | Insulators for overhead lines — Composite suspension and tension insulators for a.c. systems with a nominal voltage greater than 1000 V — Definitions, test methods and acceptance criteria |
| IEEE Std 957—2024 | IEEE Guide for Monitoring, Managing, and Cleaning of Contaminated Insulators |