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Maintenance

LS POWER GRID

Maintenance Plan

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CONFIDENTIAL

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01/22/2021	0.0	Brian Brau	Major rewrite
12/01/2022	1.0	Nick Schwarzbach	Added LSPG-NY assets
12/20/2024	2.0	Matthew Eck	Updated language, added STATCOM

Table of Contents

1.0 Introduction

Maintenance is the cornerstone of asset sustainability. An effective preventative maintenance program, combined with good operational practices, will reduce the need for much corrective and emergency maintenance, as well as total operating costs. Maintenance is performed so that equipment and systems operate efficiently and reliably. The neglect of maintenance and repairs can lead to unsafe conditions, reduced system performance, and potential regulatory action.

Maintenance includes all functions required to keep a facility operating in accordance with its original design capacities and performance. Maintenance includes repairs to broken, damaged, or worn-out equipment, periodic replacement of assets that have reached the end of their design life, and tasks designed to preserve or sustain normal operating conditions. Maintenance does not include capital improvements to facilities to increase performance, capacity, or capability.

This plan was developed with the help of various individuals representing all areas of LS Power Grid. It identifies the different programs and establishes targets for the different pieces of equipment that compose LS Power Grid's electrical transmission system. The maintenance targets were established using manufacturer recommendations and SME experience. Key areas of focus include planning, scheduling, and strategy for maintenance activities. The continued implementation of information technology will also be a focus area.

1.1 Grace Periods

The maintenance activities contained herein are intended to be performed at the maintenance intervals identified. However, maintenance tasks can be deferred for up to 25% of the interval beyond the due date (the 25% is known as the grace period) with proper approval. The grace period is meant to be used when maintenance cannot be performed by the required due date due to extraordinary system conditions or other factors and is not meant to be used routinely.

1.2 NERC Compliance

LS Power Grid performs several maintenance tasks to comply with NERC and its regional entities and are not included in this plan. These tasks are identified in their respective compliance policies (e.g. Protection System Maintenance Policy (PRC-005), Transmission Vegetation Management (FAC-003)).

1.3 Roles and Responsibilities

These are the designated duties assigned to various positions within LS Power Grid to ensure the successful implementation and oversight of the maintenance plan.

Asset Management in consultation with Field Services is Responsible for developing the Maintenance Plan document. The Transmission Field Services Team is responsible for complying with this plan, and reporting results to the Director of Transmission Field Services. The Director of Transmission Field

Services is responsible for reporting results to the Sr. Manager of Asset Management for review and analysis. Asset Management will also be responsible for entering test results into the CMMS and other systems for storing and analysis of results.

1.4 Review and Approval

This document is current as of the date on the title page. The document shall be approved by the Vice President Operations & Maintenance, the Director of Transmission Field Services and the Sr. Manager of Asset Management. CAISO will also review and approve of the document as part of the approval path.

This document shall be reviewed annually and modified whenever a significant change to maintenance strategies is identified, a new major component is added or removed, or a major asset is added or removed from LS Power Grid's electrical transmission system.

1.5 Document Maintenance

The document owner is responsible for the maintenance of the document. Responsibilities include documenting revisions, reviews, and approvals.

All changes shall be reviewed and approved via signature by the VP of Operations & Maintenance, the Director of Field Services and the Sr. Manager of Asset Management.

No minor changes will be allowed without signatory approval. These changes may be for spelling, grammar, or correcting minor deficiencies. These changes shall be tracked by increasing the document version by a fractional point value. As an example, Rev 1.0 becomes Rev 1.1 indicating one minor revision from the signatory approval.

Substantive or significant changes shall be reviewed and approved via signature. These changes shall be tracked by increasing the document version by a point value. As an example, Rev 1.0 becomes Rev 2.0.

2.0 Transmission Line

Transmission line inspections are the primary source of collecting data to develop and prioritize maintenance tasks. Having a comprehensive and well-documented inspection history is critical to successful transmission line asset management. The primary objective of transmission line inspections is to assess the condition of the line and identify asset components that require needed repairs or replacements. Effective execution of this plan will help ensure the integrity of the LS Power Grid transmission line assets such that they operate in a safe, reliable, efficient, and cost-effective manner.

This plan identifies and describes LS Power Grid's strategy for inspecting the transmission line assets. It provides guidance and a consistent approach to be utilized independent of overall ownership structure and whether LS Power Grid self- performs the work or maintained by an outside contractor.

2.1 Transmission Line Inspection Details

The specific LS Power Grid transmission line inspection details are listed in *Appendix 1: Transmission Line Inspection Components*. These details reflect the inspection item for each type of component (e.g. structures, foundations, wire, hardware, ROW).

2.2 Transmission Line Documentation and Prioritization

LS Power Grid utilizes a computer-based transmission line inspection tool. This tool has been developed in collaboration with Think Power Solutions, now called Kyro. Kyro provisions an iOS-based comprehensive management software to enable more accurate and intelligent field data collection, report creation, and historical analyses.

LS Power Grid also utilizes a computerized maintenance management system, Maximo, to document asset information and maintenance activities performed in accordance with the plan. Transmission Field Services personnel use Kyro to record transmission line maintenance & vegetation management information during each task.

Inspectors shall submit report evidence daily through Kyro as inspections are completed. The submittal shall sufficiently document the issues found. Supervisors will review daily submittals and ensure the reported information is complete and accurate.

Inspectors shall immediately report any conditions that compromise, or potentially compromise, the safe operation of the assets to the Transmission Line Manager. Such conditions may include encroachments such as buildings or trees; broken critical components such as structures, wire or insulators; excessive erosion that may compromise foundations; failed Federal Aviation Administration (FAA) mandated lights; and/or broken guy wires.

After completing the inspection, the results are reviewed to determine if any corrective action is required. The information is provided to Asset Management to be logged in the CMMS and any other systems for storing and analysis. The Transmission Line Manager will recommend any corrective action or additional preventative maintenance activities to the Director of Transmission Field Services for review. The Director of Transmission Field Services will inform and consult with the Sr. Manager of Asset Management around the appropriate level of additional maintenance to perform. Recommendations of replacing versus repairing of the asset will be made by the Director of Transmission Field Services to the Sr. Manager of Asset Management for final replace versus repair decision.

The Transmission Line Manager shall submit quarterly inspection/maintenance plans to the Director of Transmission Field Services, Sr. Manager of Asset Management, and Vice President Operations & Maintenance. The plans shall summarize forecasted inspections, previous quarter findings, actions to monitor or repair/replace, and budget impacts.

Problems found during the inspections are prioritized based on a priority ranking system. The ranking provides a time prescription for completing the corrective action based on the severity of the problem identified.

Priority Ranking	Description
P1	Address within 1 year or during the next opportunity outage
P2	Address within 1-3 years or when working in the area or line segment
P3	Address within 3-5 years or when working in the area or line segment

2.3 Transmission Line Spares

LSPG keeps stock of many spare structures, conductor, and hardware across all its utilities to respond to various risks to the transmission line system. The quantities vary based on the risks identified along with the size of the utility and any agreements in place with neighboring entities. These spares would be utilized when necessary to complete corrective actions identified from the inspections or from unexpected failure. The spare strategy is documented and reviewed annually to ensure the spare parts and equipment are adequately stocked.

2.4 Transmission Line Inspection Types and Frequencies

Inspection types and frequencies may vary from asset to asset and depend on the type of information being collected. In general, LSPG performs arial inspections once per year per transmission line right-of-way to satisfy FAC-003 requirements for vegetation management. During these flights any gross line defects observed are documented. LSPG also performs walking inspections of our above grade transmission lines and structures to account for 20% of structures per year. Some additional considerations that would influence additional inspections or higher frequencies include:

- Asset age
- Maintenance agreement with project partners and/or owners
- Warranty period provided by construction contractor and/or material supplier. See *Appendix 2: Asset Warranties*.
- Good Utility Practice
- The critical nature of the line
- Asset location considerations including weather, population, land use of easements, etc.
- The past history of transmission line asset, material supplier, etc.
- Manufacturers' recommendations
- Budget and/or manpower resources / constraints
- Line performance / line condition / past history or knowledge / structure type or some other unique asset characteristic

Inspection types include:

- Aerial
    - Typically performed from a helicopter, drone, or fixed wing aircraft
    - LiDAR or GPS enabled video recording and/or photo
    - Used to closely evaluate and photo document line components of interest
    - Used in place of climbing or bucket inspections
    - Thermal imaging
- Ground
    - Typically performed by walking, all-terrain vehicle (ATV), truck, or boat
    - Ground inspections are focused on:
        - Foundations
        - Structures
        - Conductor or hardware
        - Grounding
        - Communications
        - Lighting
        - Partial discharge (Corona)
        - Thermal imaging
        - Vegetation
        - Erosion and land use
- Elevated
    - Typically performed by bucket or climbing
    - Elevated inspections are focused on:
        - Torque
        - Fitment
        - Welded joints cracking/pitting
        - Localized damage

- Submarine
    - Typically performed by diving or underwater drone
    - Submarine inspections are focused on:
        - Visual
        - Thermal

Recommended inspection types and frequencies are identified in *Appendix 1: Transmission Line Inspection Type and Frequency.*

3.0 Substation

LS Power Grid transmits power through its network through a series of transmission substations which collect power from power generating facilities and external sources and move that power to other companies. Typical voltages are 500kV, 345kV, and 230kV. These substations typically include circuit breakers, instrument transformers, and depending on location may have reactors (fixed or variable), and series capacitors.

This plan identifies and describes LS Power Grid's strategy for inspecting and maintaining the substation and related equipment. The plan identifies certain tasks that are performed on a system wide basis as well as for individual equipment items, such as circuit breakers.

3.1 Substation Documentation and Prioritization

LS Power Grid utilizes a computerized maintenance management system to document maintenance activities performed in accordance with the plan. Transmission Field Services personnel use equipment specific datasheets to record equipment maintenance information during each task. After completing the maintenance task, the results are reviewed by Transmission Field Services to determine if any corrective action is required. The results are then provided to Asset Management to be logged in the CMMS and any other systems for storing and analysis.

Transmission Field Services personnel shall recommend any corrective action or additional preventative maintenance activities to the Director of Transmission Field Services for review. The Director of Field Services shall inform and consult with the Sr. Manager of Asset Management around the appropriate level of additional maintenance to perform. Recommendations of replacing versus repairing of the asset shall be made by the Director of Transmission Field Services to the Sr. Manager of Asset Management for final replace versus repair decision.

Problems found during the inspections are prioritized based on a priority ranking system. The ranking provides a time prescription for completing the corrective action based on the severity of the problem identified.

Priority Ranking	Description
P1	Address within 1 year or during the next opportunity outage
P2	Address within 1-3 years or when working in the area or line segment
P3	Address within 3-5 years or when working in the area or line segment

3.2 Substation Spares

LSPG keeps stock of different substation spare parts and equipment across all its utilities to respond to different risks to the substations. The quantities vary based on the risks identified along with the size of the utility and any agreements in place with neighboring entities. These spares would be utilized when necessary to complete corrective actions identified from the inspections or from unexpected failure of an asset. The spare strategy is documented and reviewed annually to ensure the spare parts and equipment are adequately stocked.

3.3 Substation System Wide

Substation System Wide Maintenance Task	Frequency
Visual Inspections	Monthly
Thermographic Imaging	Condition Based

System Wide assessments are primarily accomplished through visual inspections. Visual inspections consist of a monthly periodic observation of the substation and related equipment. This involves the major equipment and miscellaneous equipment including switches, CTs, rigid bus, strain bus, fence, yard condition, foundations, and structures among others. Major equipment Visual Inspections are identified by their individual inspection forms. Miscellaneous equipment Visual Inspections are identified in *Appendix 3: Substation Miscellaneous Equipment Visual Inspection Form*. These inspections include various component checks as well as any minor maintenance activities needed to address any identified problems. All identified issues will be logged into the computerized maintenance management system and promptly addressed.

Thermographic imaging is the process of analyzing electrical equipment using infrared technology to identify electrical components that are generating abnormal excess levels of thermal radiation. Abnormal excess levels of thermal radiation are commonly associated with equipment malfunctions that can lead to catastrophic equipment failure. Using thermographic imaging, equipment malfunctions can be identified and addressed prior to complete equipment failure. LS Power Grid utilizes thermographic imaging on a condition-based assessment (confirming suspicions prior to de-energizing equipment).

3.4 Substation Gas (SF_6) Circuit Breakers

Substation Gas (SF_6) Circuit Breakers	Frequency
Visual Inspections	Monthly
Complete Breaker Maintenance	5 Years
Internal Inspection	Condition Based

Visual Inspections

The Substation Gas (SF_6) Circuit Breakers will be visually inspected as part of the Substation System Wide Maintenance Task. During the inspection the maintenance personnel shall document the condition of each circuit breaker on the Monthly Gas (SF_6) Circuit Breaker Inspection Form included in *Appendix 4: Substation Gas (SF_6) Circuit Breaker Monthly Inspection Form.* Inspections generally include:

- Check bushing porcelain condition
- Check HV ground connection
- Check lights and heaters for proper operation (anti-condensation heaters and mechanism anti-condensation heaters)
- Check for loose bolts
- Check for signs of rust, discoloration, or corrosion
- Check relay (SEL-2411)

These assessments shall be compared with previous inspections to alert maintenance personnel of any health degradation. In addition, the following measurable items shall be checked and recorded:

- Check and record gas (SF_6) pressure and density
- Record the number of operations
- Check and record the motor start counter
- Check and record hydraulic oil level in the mechanism

These recorded values shall be compared against acceptable operating ranges identified in *Appendix 6: Substation Gas (SF_6) Circuit Breaker Typical Inspection Value Ranges.* The Maintenance Manager shall be notified promptly of any values recorded outside these typical ranges and a corrective plan established.

Complete Breaker Maintenance

Complete Breaker Maintenance tasks will be performed on the Substation Gas (SF_6) Circuit Breakers. These tasks include general maintenance inspection and testing, operating mechanism maintenance, and gas (SF_6) testing. Maintenance personnel shall document the condition of each breaker on the Annual Gas (SF_6) Circuit Breakers Inspection Form included in *Appendix 5: Substation Gas (SF_6) Circuit Breaker 5-Year Inspection Form.*

The general maintenance inspection and testing includes those items identified in the Visual Inspection in addition to the following:

- Power factor test
- Insulation resistance test
- Pole resistance test
- Check bushing hardware tightness
- Check tank hardware tightness
- Check rupture disk hardware tightness
- Clean entrance bushings

- Check bushing insulators for cracks
- Touch-up chipped paint on frame
- Check anti-pumping circuit
- Check alarms and lockouts

Operating mechanism maintenance is critical to ensuring the proper operation of the various circuit breaker components. Operating mechanism maintenance includes:

- Perform timing tests
- Verify mechanism limit switch settings
- Check charging motor brushes for excess wear
- Check auxiliary switches for proper adjustment
- Check mechanism mounting hardware/wiring for tightness
- Clean and lubricate linkages
- Confirm mechanism operation with a breaker test operation
- Perform mechanism travel analysis during test operation

The results of the travel analysis shall be compared with previous tests values to verify mechanism travel and reaction times are consistent. Analysis of physical measurement and trend data will be used to identify potential failure modes and allow time for corrective action prior to catastrophic failure.

Gas (SF_6) testing is the last major activity of the Complete Breaker Maintenance. Since gas (SF_6) serves as the insulating and arc quenching medium within the pole tanks, it is essential that the proper gas (SF_6) density and moisture be maintained. Gas (SF_6) density is checked by measuring pressure as a function of temperature. Tested values will be compared with previous values to detect and gas (SF_6) leaks.

High moisture content in the circuit breaker can lead to flashovers in the interrupter. A moisture analyzer is used to measure the moister content of the gas (SF_6) in each pole unit.

Gas (SF_6) testing includes:

- Check gas (SF_6) density and density monitor for correctness
- Check gas (SF_6) moisture content
- Leak test all flanges, fittings, and gas sealing connections

<u>Internal Inspections</u>

Substation Gas (SF_6) Circuit Breaker Internal Inspection is performed based on the circuit breaker condition that is determined from the Complete Breaker Maintenance tasks. Internal Inspections may also be conducted based on a cumulative fault duty or upon large, near design limit faults. The Senior Field Operations Manager shall assess when an Internal Inspection should be performed and provide a recommendation to the Vice President Operations & Maintenance and Asset Manager. An Internal Inspection includes visual inspection of contacts and head internals, replacement of desiccants, etc. plus all Complete Breaker Maintenance tasks.

3.5 Substation Gas-Insulated Switchgears (GIS)

Substation Gas-Insulated Switchgears (GIS)	Frequency
Surface Sealing Inspection	24 Months
Visual Inspection	Monthly
DC Control Circuitry Inspection	NERC PRC-005-6
Major Inspection	Condition Based
Contact System Inspection	Condition Based
Revision	25 Years

Surface Sealing Inspection

The surface sealing coating of the GIS equipment will be visually inspected for incipient corrosion.

Visual Inspections

The GIS will be visually inspected as part of the Substation System Wide Maintenance Task. Inspections generally include:

- Check exterior, record operating cycle counter reading
- Check and repair the anti-corrosion agent
- Check rupture disc with protection plate for damage
- Check function of anti-condensation heaters in drive housings and cabinets
- Check the fixing of the cable and cable glands, and if required tighten the terminals
- Check the pressure of the gas filling with precision pressure gauge
- Check function of the density monitor

DC Control Circuitry Inspection

LS Power Grid Operating Procedure – Protection System Maintenance Program, defines the tasks and frequency required for the DC Control Circuitry Inspection and Tests. This Operating Procedure embodies the latest industry standards and applicable NERC compliance obligations. Specific compliance obligations are identified in NERC PRC-005-6 – Protection System, Automatic Reclosing, and Sudden Pressure Relaying Maintenance.

The DC Control Circuitry Inspection includes the following:

- Function check of release circuits
- Function check of closing lockout
- Function check of General lockout SF6
- Check anti-pump function
- Check control function

Major Inspection

Complete GIS Maintenance tasks will be performed on the GIS system. These tasks include general maintenance inspection, Gas-related work, Circuit Breaker, Disconnector and Earthing switches, Expansion joint, and Current and Voltage converter and RC voltage divider.

The complete GIS maintenance inspection includes those items identified in the Visual Inspection in addition to the following:

- Check overall cleanliness and clean as necessary

Gas-related work maintenance includes:

- Extract the (SF_6) gas by suction
- Replace filters
- Evacuate gas compartment and fill with (SF_6) gas
- Check moisture content of the (SF_6) gas
- Measure (SF_6) air content
- Perform leakage detection when the installation is ready for operation

Circuit Breaker maintenance includes:

- Check Drive
- Visual inspection of contact system
- Check electrical connections and tighten terminals if necessary

Disconnector and Earthing Switches/Module maintenance includes:

- Check drive
- Visual check on switching system
- Check electrical connections and tighten terminals if necessary

Expansion Joint maintenance includes:

- Check setting of tie rods on the removal link. Fasten screw connections as specified
- Current and Voltage converter and RC voltage divider maintenance includes
- Electrical connections in terminal box or control cabinet to be checked, tighten if necessary

Contact System Inspection

The Contact system inspection is based on the conditions of the circuit breakers and/or high-speed Earthing switches.

Circuit Breakers:

- When the max permissible number of switching operations is reached

High-speed Earthing Switches:

- After every 2nd switching into connection with high-voltage parts

Revision

The revision of the GIS system is based upon time or the conditions of the circuit breakers and/or earthing switches.
Circuit Breakers:

- 6,000 mechanical operating cycles

Work-in-progress Earthing Switch and Disconnector:

- After 6,000 mechanical operating cycles

High-speed Earthing Switches:

- After 2,000 mechanical operating cycles

3.6 Substation Circuit Switchers

Substation Circuit Switchers	Frequency
Visual Inspections	Monthly
Complete Switcher Maintenance	5 Years

The Substation Circuit Switchers provide an integral substation component by providing protection to various devices including transformers, shunt reactors, and series capacitor bypassing.

Visual Inspections

The circuit switchers will be visually inspected as part of the Substation System Wide Maintenance Task. Inspections generally include:

- Check ground connection
- Check for loose bolts
- Check for signs of rust, discoloration, or corrosion
- Check lights and heaters for proper operation
- Check for low gas (SF_6) pressure target

Complete Switcher Maintenance

Complete Switcher Maintenance tasks will be performed on the Substation Switches. These tasks

include general maintenance inspection, switch operator, interrupter, and disconnect live parts.

The general maintenance inspection includes those items identified in the Visual Inspection in addition to the following:

- Check overall cleanliness and clean as necessary

Switch operator maintenance includes the following:

- Check for evidence of water ingress, damage, excessive corrosion or wear
- Check for ease of operation during slow, manual cranking using the switch operator manual operating handle

- Check for loose wiring inside enclosure and proper functioning of position-indicating lamps, operation counter, etc.

Power train maintenance includes the following:

- Check for evidence of damage, excessive corrosion or wear
- Check tightness of fasteners
- Check for ease of operation during slow, manual cranking using the switch operator manual operating handle. Verify for complete stroking of the various drive levers against their stops and for attainment of over toggle positions.
- Check condition of seals

Interrupter maintenance includes the following:

- Check for low gas (SF_6) pressure (red indicator)
- Check tightness of fasteners on current-carrying parts

3.7 Substation Transformers / Shunt Reactors

Substation Transformers / Shunt Reactors	Frequency
Visual Inspections	Monthly
Dissolved Gas Analysis (DGA) Test	Annually
Dehydrating Filter Breather Maintenance	Annually
Complete Transformer / Shunt Reactor Inspection and Testing	5 Years
Internal Winding Inspections	25 Years

Transformers and Shunt Reactors perform very different functions. Transformers are designed for efficient power transfer from one voltage system to another, a shunt reactor is intended only to consume VARs. Although they function differently, they are very similar in construction and the maintenance activities are the same.

Visual Inspections

The Transformers and Shunt Reactors will be visually inspected as part of the Substation System Wide Maintenance Task. During the inspections the maintenance personnel shall document the condition of each transformer and shunt reactor on the inspection form included in *Appendix 7: Substation Transformer / Shunt Reactor Monthly Inspection Form*. Inspections generally include:

- Check bushing porcelain condition
- Check HV ground connection
- Check lights and heaters for proper operation
- Check for loose bolts
- Check for signs of rust, discoloration, or corrosion
- Check for oil leaks
- Check oil containment berm for damage

These assessments shall be compared with previous inspections to alert maintenance personnel of any health degradation. In addition, the following measurable items shall be checked and recorded:

- Check and record main tank oil level
- Check and record constant oil preservation system (COPS) tank oil level
- Check and record bushing oil level
- Record present winding temperature
- Record maximum winding temperature
- Record present oil temperature
- Record maximum oil temperature
- Record surge arrestor counter
- Record total dissolved concentration gas (TDCG) value
- Record moisture level
- Record tap changer counter
- Record relative humidity value
- Record relative humidity sensor temperature

These recorded values shall be compared against acceptable operating ranges identified in *Appendix 9: Substation Transformer / Shunt Reactor Typical Inspection Value Ranges*. The Maintenance Manager shall be notified promptly of any values recorded outside these typical ranges and a corrective plan established.

Dissolved Gas Analysis (DGA) Test

One of the most useful condition assessment techniques involves sampling and analysis of dissolved gases in the oil of operating transformers and shunt reactors. The DGA can be used to determine the type and severity of an electrical fault. The results of the analysis can indicate a wide range of transformer / shunt reactor conditions and malfunctions, both thermal and electrical, which could lead

to failure of major electrical equipment if corrective measures are not taken.

The DGA test shall test for the following gases:

- Hydrogen (H_2)
- Methane (CH_4)
- Acetylene (C_2H_2)
- Ethylene (C_2H_4)
- Ethane (C_2H_6)
- Carbon Monoxide (CO)
- Carbon Dioxide (CO_2)
- Total Dissolved Concentration

These recorded values shall be compared with previous values to identify any early trends and against acceptable operating ranges identified in *Appendix 9: Substation Transformer / Shunt Reactor Typical Inspection Value Ranges*. The Maintenance Manager shall be notified promptly of any values recorded outside these typical ranges and a corrective plan established including any additional tests.

Dehydrating Filter Breather Maintenance

Check for discoloration of the silica gel in the breather due to moisture in the breathed-in-air. If discolored, replace silica gel and oil in the oil pot.

Complete Transformer / Shunt Reactor Inspection and Testing

Complete transformer and shunt reactor testing is performed to assess the transformer windings for abnormalities and evaluate the general operation of the transformer / shunt reactor auxiliary systems. In addition to the Visual Inspections, the following tests will be performed:

- Power factor test on the transformer windings, bushings and associated transformer arrestors
- Winding resistivity test
- Winding insulation resistance test
- Transformer turns ratio test
- Cooling fan, cooling fan motor, and cooling fan control cabinet systems test. Check for corrosion.
- Visually inspect and confirm operation of protective relays (Buchholz, rapid pressure rise, and pressure relief device), level gauges, and indicators.
- Inspect bushings for bolt looseness, rust, leaking oil

Additional insulating oil tests are used to evaluate both the immediate acceptability and the degree of aging/degradation on the insulating oil. These tests include:

- Moisture content
- Dielectric strength breakdown voltage (BDK) test

- Oil power factor test
- Oil resistivity
- Acid value test

These tests evaluate the dielectric properties, contaminants, and acidity of the oil to assess whether the transformer / shunt reactor oil provides adequate dielectric insulation.

Dielectric tests measure the voltage at which the oil breaks down. This is indicative of the amount of contaminant (usually moisture) in the oil. In general, the moisture content in the oil lowers the insulating system dielectric strength and allows flashover that can damage a transformer. The power factor of the oil indicates the dielectric loss of the insulating oil and thus its dielectric heating. Similar to the moisture test, the acid value test indicates whether the insulating oil contains any contaminates.

Internal Winding Inspection

For the Internal Winding Inspection, the transformer / shunt reactor oil tank will be emptied and the windings and supporting blocks and structures will be visually inspected. The oil will be tested and reprocessed and/or replaced with new oil.

3.8 Substation Series Compensation System

Substation Series Compensation System	Frequency
Visual Inspections	Monthly
Series Compensation System Maintenance	Annual

The Series Compensation System consists of a bank of capacitors arranged in series and parallel that are installed in series with the High Voltage (HV) transmission line. The primary function of the series compensation system is to decrease the effective impedance of a transmission line, thereby increasing the transmission line power transfer capability. The series compensation system consists of many devices most of which are critical pieces of equipment that are part of the parallel protective system that prevents damage to the capacitors during power system faults. The protective system design requires the careful selection and coordination of several components including the By-Pass Circuit Breaker, the Metal Oxide Varistor (MOV), and the Triggered Air Gap (TAG), if used. Additionally, the Series Compensation System consists of many pieces of equipment that are referenced elsewhere in this maintenance plan. For those items reference the applicable Maintenance Plan section. The primary components of the Series Compensation System include:

- Metal Oxide Varistor (MOV): The MOV is connected in parallel with the capacitors and are used to protect the capacitors from overvoltage during system faults.
- Triggered Air Gap (TAG): If used, the TAG conducts to limit the energy absorbed by the MOV.
- Discharge Damping Circuit: Most commonly consists of a reactor only, but may also include non-linear resistors, and is used to limit capacitor discharge current.

- Bypass Circuit Breaker: This circuit breaker closes rapidly to limit both MOV and TAG energy, removing the series capacitors from service. This switch is also used for normal switching to insert the series capacitors or bypass them. External motor operated switches are used to isolate the series capacitor bank.

Visual Inspections

The Series Compensation System will be visually inspected as part of the Substation System Wide Maintenance Task. During the inspections the maintenance personnel shall document the condition of each capacitor bank on the inspection form included in *Appendix 10: Substation Compensation System Monthly Inspection Form*. Inspections generally include:

Capacitor Bank Visual Inspection Tasks

- Check wires and electrical connections
- Check capacitor surface conditions for surface damage or corrosion
- Check for oil leaks
- Check for loose bolts
- Inspect isolators

Metal Oxide Varistor

- Check electrical connections
- Check porcelain condition

Damping Reactor & Resistor (if-used)

- Check isolators
- Check for resin

Triggered Air-Gap (if-used)

- Check Enclosures
- Check Electrodes
- Check bolt tightness
- Check MOV
- Check Louvers
- Check Plasma Injector (if applicable)
- Check high voltage cables
- Check high voltage bushings

Bypass Circuit Breaker

- Bypass Circuit Breaker maintenance in accordance with Section 3.4

Series Compensation System Maintenance

Series Compensation System Maintenance tasks will be performed on the entire Series Compensation System annually. These tasks include general maintenance inspection and testing, and preventative/corrective maintenance on each series compensation system component. Maintenance personnel shall document the condition of each system component on the Series Compensation System Inspection Form included in *Appendix 11: Substation Series Compensation System Annual Inspection Form.* In addition to the Visual Inspections, the following tests will be performed:

Capacitor Bank Visual Inspection Tasks

- Perform random torque verification
- Measure a sample of individual capacitor capacitance values

Metal Oxide Varistor

- Perform random torque verification

Damping Reactor & Resistor (if-used)

- Measure DC winding resistance (R)
- Measure Inductance (L)

Triggered Air-Gap (if-used)

- Perform random torque verification
- Verify gap settings and adjust if necessary
- Measure TAG capacitor capacitance
- Measure Varistor Analog and Pulse (VAP) energy (mC)
- Measure VAP energy (V)
- Measure VAP current (A)
- Record counter increment
- Perform trigger circuit and plasma injector test +10kV (if applicable)
- Perform trigger circuit and plasma injector test – 10kV (if applicable)
- Perform trigger circuit and plasma injector current injection test (if applicable)
- Record trigger circuit and plasma injector counter operation (if applicable)

Bypass Circuit Breaker

- Bypass Circuit Breaker maintenance in accordance with Section 3.4

3.9 Substation Oil Spill Containment System

Substation Oil Spill Containment System	Frequency
Visual Inspections	Monthly
Oil Spill Containment Pumping	Condition Based

Visual Inspections

The oil spill containment system will be visually inspected as part of the Substation System Wide Maintenance Task. The oil spill containment system condition will be inspected including checking for water collecting.

Oil Spill Containment Pumping

During the Visual Inspections, the pump will be operated to drain any standing water if the spill containment system has collected water. Maintenance is required more often during seasons of heavy rain to clear water collecting in the oil containment pit and to ensure the sump motor is operating correctly.

3.10 Substation Outdoor Disconnect Switches

Substation Outdoor Disconnect Switches	Frequency
Visual Inspections	Monthly
Motor Operated Disconnect Switch Inspection and Test	5 Years
Manual Operated Disconnect Switch Inspection and Test	5 Years

Outdoor disconnect switches are used to completely electrically isolate various substation equipment, such as circuit breakers, transformers, and incoming transmission lines, from other energized elements. This additional protection minimizes the opportunity for accidental energization and provides safe and efficient substation equipment service or maintenance. To minimize outages, disconnect switch maintenance shall be performed with associated equipment maintenance.

Visual Inspections

The disconnect switches will be visually inspected as part of the Substation System Wide Maintenance Task. Inspections generally include:

- Check ground connection
- Check for loose bolts
- Check for signs of rust, discoloration, or corrosion
- Check if numbering is visible

- Check cabinet cleanliness
- Check if coupled
- Check and record operation counter

Motor Operated Disconnect Switch Inspection and Test

Motor operated disconnect switches rely on an electric motor to drive the gear mechanism at the proper torque and speed necessary for successful switch operation. Inspection and tests include:

- Uncouple motor operator from vertical operating pipe and electrically test motor operator while uncoupled to verify operation and appropriate setting of position indicators.
- Couple motor operator back to the vertical operating pipe and electrically test motor operator with switch coupled to verify switch operation. Operate the switch several times electrically and confirm appropriate setting of position indicators.

After reviewing the inspection and test results, the Senior Field Operations Manager shall make a determination of whether additional maintenance is required and whether disconnect inspection intervals should be adjusted.

Manual Operated Disconnect Switch Inspection and Test

Manual operated disconnect switches relay on a manual hand crank to operate the switch. Inspection and tests include:

- Manually operate switch to confirm proper operation
- Confirm position indicator settings during operation

3.11 Substation Surge Arresters

Substation Surge Arresters	Frequency
Visual Inspections	Monthly
Surge Arrester Tests	10 Years

Substation surge arresters are the primary protection against atmospheric and switching over voltages.

Visual Inspections

The surge arresters will be visually inspected as part of the Substation System Wide Maintenance Task. Inspections include:

- Check bushing porcelain condition
- Check jumper connections
- Check for loose bolts
- Check for signs of rust, discoloration, or corrosion

- Check ground connection

Surge Arrester Tests

The Surge Arrester test is performed to evaluate the integrity of the surge arrester. The tests include:

- Insulation resistance test from phase terminal(s) to case for one (1) minute

3.12 Substation Station Service Voltage Transformers

Substation Station Service Voltage Transformers	Frequency
Visual Inspections	Monthly
Complete Station Service Voltage Transformer Inspection and Tests	8 Years
Dissolved Gas Analysis (DGA) Test	3 Years

The Substation Station Service Voltage Transformers provide the primary power supply to the substation.

Visual Inspections

The station service voltage transformers will be visually inspected as part of the Substation System Wide Maintenance Task. Inspections generally include:

- Check for loose bolts
- Check and record transformer oil level and gauge
- Check for oil leaks
- Check for signs of rust, discoloration, or corrosion

Complete Station Service Voltage Transformer Inspection and Tests

A complete station service voltage transformer testing is performed to assess any abnormalities and identify any potential issues with the operation of the main power supply. To minimize outages, these inspections and tests shall be performed at the frequency identified or closest outage opportunity. In addition to the Visual Inspections, the following tests will be performed:

- Transformer turns ratio test on the as found tap position
- Power factor test
- Ground resistor resistance test

3.13 Substation Instrument Transformers

Substation Instrument Transformers	Frequency
Visual Inspections	Monthly
Complete Instrument Transformers Inspection and Tests	NERC PRC-005-6

The Substation Instrument Transformers are an essential component for the safe and efficient operation of the transmission system. They provide accurate and reliable current and voltage measurements for secondary equipment such as meters, protection relays, computers, and other devices. Instrument transformers consist of various styles including:

- Bushing current transformers (CT)
- Capacitor voltage transformer (CVT)
- Potential transformer (PT)

Visual Inspections

The instrument transformers will be visually inspected as part of the Substation System Wide Maintenance Task. Inspections generally include:

- Check porcelain condition
- Check for loose bolts
- Check for signs of rust, discoloration, or corrosion
- Check and record oil level

Complete Instrument Transformers Inspection and Tests

LS Power Grid Operating Procedure – Protection System Maintenance Program, defines the tasks and frequency required for the Complete Instrument Transformers Inspection and Tests. This Operating Procedure embodies the latest industry standards and applicable NERC compliance obligations. Specific compliance obligations are identified in NERC PRC-005-6 – Protection System, Automatic Reclosing, and Sudden Pressure Relaying Maintenance.

3.14 Substation Ground Grid

Substation Ground Grid	Frequency
Visual Inspections	Monthly
Complete Ground Grid Inspection and Tests	Condition Based

The Substation Ground Grid primary objective is to prevent electric shock and to mitigate overvoltage that can damage equipment. Ground grids are installed below grade such that currents flowing in from the above grade steel structures or shield wire(s) are easily dissipated into the earth.

Visual Inspections

The ground grid will be visually inspected as part of the Substation System Wide Maintenance Task. Inspections generally involve where the ground grid comes above grade and makes various connections and include:

- Check for loose bolts
- Check for damaged to exposed ground conductors

Complete Ground Grid Inspection and Tests

A Complete Ground Grid Inspection and Tests are condition based and typically only performed on a relay mis-operation or other significant event. These inspections and tests include:

- Check bolted electrical connections for high resistance
- Perform point-to-point tests to determine resistance between main grounding system and all major electrical equipment frames, system neutrals, and/or derived neutral points.

3.15 Substation Battery Banks and Battery Chargers

Substation Battery Banks and Battery Chargers	Frequency
Visual Inspections	Monthly
Complete Battery Bank and Battery Charger Inspection and Tests	NERC PRC-005-6

The Substation Battery Banks and Battery Chargers are one of the most important components of the transmission system. They ensure all the essential electrical systems in the substation continue to operate in the event of a power outage.

Visual Inspections

The battery banks and battery chargers will be visually inspected as part of the Substation System Wide Maintenance Task. During the inspections the maintenance personnel shall document the condition of each battery bank and battery charger on the inspection form included in *Appendix 12: Substation Battery/Charger Monthly Inspection Form*. Inspections generally include:

- Check for loose bolts
- Check for signs of rust, discoloration, or corrosion
- Check water levels
- Check eye wash station for expired solution

These assessments shall be compared with previous inspections to alert maintenance personnel of any health degradation. In addition, the following measurable items shall be checked and recorded:

- Record battery room temperature

- Record battery charger float voltage
- Record battery charger float amps
- Record the following for each pilot cell: volts, hydrometer, electrolyte temperature and calculate the corrected reading.

Complete Battery Bank and Battery Charger Inspection and Tests

LS Power Grid Operating Procedure – Protection System Maintenance Program, defines the tasks and frequency required for the Complete Battery Bank and Battery Charger Inspection and Tests. This Operating Procedure embodies the latest industry standards and applicable NERC compliance obligations. Specific compliance obligations are identified in NERC PRC-005-6 – Protection System, Automatic Reclosing, and Sudden Pressure Relaying Maintenance.

3.16 Substation Meters and Relays

Substation Meters and Relays	Frequency
Visual Inspections	Monthly
Complete Meter and Relay Inspection and Tests	NERC PRC-005-6

The meters and relays are devices that detect abnormal conditions and are designed to initiate a trip signal to disconnecting devices to isolate possible faults or equipment failures.

Visual Inspections

The meters and relays will be visually inspected as part of the Substation System Wide Maintenance Task. Inspections generally include:

- Check for targets
- Check for any alarm conditions

Complete Meter and Relay Inspection and Tests

LS Power Grid Operating Procedure – Protection System Maintenance Program, defines the tasks and frequency required for the Complete Meter and Relay Inspection and Tests. This Operating Procedure embodies the latest industry standards and applicable NERC compliance obligations. Specific compliance obligations are identified in NERC PRC-005-6 – Protection System, Automatic Reclosing, and Sudden Pressure Relaying Maintenance.

3.17 Substation Communication System

Substation Communication System	Frequency
Communication System Inspection and Tests	NERC COM-001

The Substation Communication System includes the telecommunication facilities and WAN communications. The communication system enables voice and/or data between control centers, Regional Transmission Organizations (RTOs), adjacent transmission operators, connected generator operations, and related parties to maintain system reliability.

Communication System Inspection and Tests

LS Power Grid Operating Procedure – Communications, defines the tasks and frequency required for the Communication System Inspection and Tests. This Operating Procedure identifies the compliance obligation established in NERC COM-001-3 – Communication.

3.18 Substation Control Enclosure and Yard

Substation Control Enclosure and Yard	Frequency
Visual Inspections	Monthly
Control Enclosure HVAC Equipment Tests	Annually
Fire Suppression System Tests	Annually
Equipment Painting	15 Years
Mowing/Spraying	Condition Based
Fence Painting	5 Years
Road Grading	3 Years

Visual Inspections

The substation control enclosure and yard will be visually inspected as part of the Substation System Wide Maintenance Task. Inspections of the control enclosure and yard generally include:

- Check exterior, doors, and foundation for signs of deterioration and/or damage
- Check ground connections
- Check overall cleanliness
- Check condition of fire extinguishers
- Check adequate first aid supplies
- Check security cameras
- Check for any alarms or relay targets
- Check proper operation of heater and air conditioner
- Check inside control enclosure lights and yard lights
- Check for vegetation growth
- Check yard and perimeter of fence for any washouts
- Check for any filter fabric visible due to erosion

Control Enclosure HVAC Equipment Testing

The HVAC Equipment Tests include a full operational check including:

- Check for fans for proper air velocity (and fan belts if applicable)
- Check for proper ventilation and air flows
- Check cooling and heating capabilities
- Check and clean coils
- Check and replace filters
- Check dampers for proper balance
- Check thermostat operation

Fire Suppression System Test

The Fire Suppression System will be tested by a qualified testing agency to ensure proper operation.

Equipment Painting

Equipment shall be painted to minimize corrosion as needed but no less than specified.

Mowing/Spraying

The grounds shall be kept in good condition with grass mowing and weed spraying as needed.

Fence Painting

Fences shall be properly maintained and painted to minimize corrosion as needed but no less than specified.

Road Grading

Proper care for access roads is critical to ensure safe and efficient operations and maintenance of the transmission system. Access roads shall be graded and inspected for erosion as needed but no less than specified.

3.19 STATCOM

LS Power Grid operates and maintains STATCOMs (Static Synchronous Compensator). These are assets that can absorb or provide reactive current to regulate voltage at the point it connects to the system. They are utilized to improve power quality and system stability for the grid. STATCOMs accomplish this by controlling the reactive power follow dynamically and reducing the voltage and current harmonics.

This plan identifies and describes LS Power Grid's strategy for inspecting and maintaining the STATCOM and related equipment. LSPG has entered into a Long-Term Service Agreement (LTSA) of 15 years with Siemens who is the equipment manufacturer and builder of the STATCOM. With this LTSA is a

manufacturer recommended maintenance plan. The plan identifies certain tasks that are performed by Siemens or by LSPG and to what frequency. See *Appendix 13: The STATCOM Maintenance Outline Annual Preventative Maintenance Scope* document.

3.20 STATCOM Spares

LSPG keeps stock of different spare parts and equipment specifically for the STATCOM to respond to different risks to the system. LSPG stocks all vendor recommended spares. These spares would be utilized when necessary to complete corrective actions identified from the inspections or from unexpected failure of the equipment. The spare strategy is documented and reviewed annually to ensure the spare parts and equipment are adequately stocked.

3.21 STATCOM Inspections & Reporting

Given the LTSA with Siemens, the STATCOM inspection tasks are broken out between LSPG as the Owner and Siemens. The LSPG Owner inspection items are monthly and are primarily accomplished through visual inspections. Visual inspections consist of a monthly periodic observation of the STATCOM and related equipment. These inspections include various component checks as well as any minor maintenance activities needed to address any identified problems with the STATCOM equipment or components. All identified issues will be logged into the computerized maintenance management system and promptly addressed.

3.22 STATCOM Maintenance Activities

Attached as Appendix 13: STATCOM Maintenance Outline is a breakdown of the Siemens recommended maintenance. The document indicates the equipment to be maintained, responsible party for the maintenance activity, and the frequency for completion either monthly, annually, or by some other frequency. LSPG will follow the recommended schedule for the duration of the LTSA.

4.0 Reference Documents
IEEE C57.104 – Guide for the Interpretation of Gas Generated in Oil-Immersed Transformers
IEEE C57.106 – Guide for the Acceptance and Maintenance of Insulating Oil in Equipment
IEEE C37.09 – Standard Test Procedure for AC High-Voltage Circuit Breakers
NERC PRC-005-6 – Protection System, Automatic Reclosing, and Sudden Pressure Relaying Maintenance
NERC COM-001-3 – Communications

Appendix 1: Transmission Line Inspection Type and Frequency

Transmission Line Asset	Inspection Type and Frequency (months) Aerial	Ground (Note 1)	Drone	Foundation	Submarine	Partial Discharge (Corona)
Gray - Tesla	12	60	Note 2	Note 2	N/A	Note 3
Tule Canyon - Cross	12	60	Note 2	Note 2	N/A	Note 3
Cross - Tesla	12	60	Note 2	Note 2	N/A	Note 3
Alibates - Railhead	12	60	Note 2	Note 2	N/A	Note 3
Railhead - Gray	12	60	Note 2	Note 2	N/A	Note 3
Gray - Alibates	12	60	Note 2	Note 2	N/A	Note 3
Gray - Allen Creek	12	60	Note 2	Note 2	N/A	Note 3
Limestone - Gibbons Creek	12	60	Note 2	Note 2	N/A	Note 3
Duff - Coleman	12	60	Note 2	Note 2	N/A	Note 3
Silver Run - Hope Creek (Aboveground)	12	60	Note 2	Note 2	N/A	Note 3
Silver Run - Hope Creek (Undersea)	N/A	N/A	N/A	N/A	60	N/A
Edic - Princetown (351/352)	12	60	Note 2	Note 2	N/A	Note 3
Edic - Princetown (351)	12	60	Note 2	Note 2	N/A	Note 3
Edic - Princetown (352)	12	60	Note 2	Note 2	N/A	Note 3
Princetown - Gordon Road (371)	12	60	Note 2	Note 2	N/A	Note 3
Edic - Gordon Road (14)	12	60	Note 2	Note 2	N/A	Note 3
Princetown - New Scotland (55)	12	60	Note 2	Note 2	N/A	Note 3
Princetown - New Scotland (361/362)	12	60	Note 2	Note 2	N/A	Note 3
Gordon Road - Rotterdam (30)	12	60	Note 2	Note 2	N/A	Note 3
Gordon Road - Rotterdam (31)	12	60	Note 2	Note 2	N/A	Note 3

Notes:

1. 5-year cycle – a minimum of 20% of structures shall be tested per year; including structure grounding measurement
2. These items are to be inspected on a condition basis depending on results from other inspection types.
3. Partial discharge should be considered when an asset age approaches 20 years.

Appendix 2: Transmission Line Inspection Components

Inspection Items	Structure Type			
	Monopole	Lattice	H-frame	Transition Structure
General integrity	✓	✓	✓	✓
Vertical alignment	✓	✓	✓	✓
Impact damage	✓	✓	✓	✓
Fire damage	✓	✓	✓	✓
Standing water damage / evidence	✓	✓	✓	
Foreign objects attached to the structure such as birds' nests or vines	✓	✓	✓	✓
Missing or faded signage (structure number, danger signs, etc.)	✓	✓	✓	✓
Rust and/or discoloration of steel / galvanizing	✓	✓	✓	✓
Splitting, cracking or holes	✓	✓	✓	✓
Integrity of the anti-corrosion collar (ground sleeve)	✓	✓	✓	✓
Arms - twisted or not securely attached	✓	✓	✓	✓
Ladder clips - intact, secure	✓		✓	✓
Pole section connections (flange) - nuts/bolts secure	✓	✓	✓	✓
Cross bracing - bent, broken, missing, cracked, loose			✓	✓
Members / member hardware - intact, not loose, not cracked		✓		✓
Vessel Collison Protection System				✓
Buoy Inspection				✓

Notes:

1. Monopoles include all variations of poles - single, double, and triple monopole structures
2. Lattice includes all variations of lattice structures including guyed V-lattice structures
3. Transition structures are the SRE structures that transition from undersea cable to overhead transmission. The Delaware River structure (DE-15) shall be inspected quarterly.

Appendix 2: Transmission Line Inspection Components

Inspection Items	Foundation Type				
	Direct Embed	Drilled Pier	Helical Pier	Caisson	Guy Anchors - Soil/Rock
Change in ground line profile due to filing, excavation or erosion	✓	✓	✓	✓	✓
Anchor bolt cage - bolts intact and secure; integrity		✓	✓		
Backfill condition at ground surface	✓			✓	✓
Condition of concrete pier at surface - cracking, spalling, rebar exposed, settlement		✓	✓	✓	
Condition of caisson at surface or extended reveal - steel: weld integrity, rusting; concrete - cracking, spalling, rebar exposed, settlement				✓	
Integrity - bent, broken eye, rusted, pulling out					✓
Attachment hardware secure					✓

Appendix 3: Substation Miscellaneous Equipment Visual Inspection Form

Substation:
Date: **Gate Locked** **Yes / No**
Inspector:

Disconnect Switces OK
1. Grounds
2. Hardw are
3. Rust/Corrosion
4. Numbering
5. Coupled

Notes

Ground Grid ~~OK~~
1. Hardware
2. Damaged Conductors

Notes

Yard ~~OK~~
1. Lights
2. Vegetation Grow th
3. Fence
4. Visible Fabric Filter
5. Grounds

Notes

Oil Spill Containment OK
1. Condition
2. Water Present

Notes

Surge Arresters Ok
1. Porcelain Condition
2. Jumpers
3. Hardw are
4. Rust/Corrosion
5. Grounds

Notes

Control Building ~~Ok~~
1. Cleanliness
2. Cameras
3. HVAC
4. Lights
5. Grounds
6. Fire Ex tinguisher
7. First Aid
8. Door/Foundation

Notes

SSVT ~~OK~~
1. Hardware
2. Oil Lev el
3. Oil Leaks
4. Rust/Corrosion

Notes

Instrument Transformers OK
CTs
1. Porcelain Condition
2. Hardw are
3. Rust/Corrosion
4. Oil Lev el

PTs / CVTs
1. Porcelain Condition
2. Hardware
3. Rust/Corrosion
4. Oil Lev el

Notes

Circuit Switchers ~~OK~~
1. Grounds
2. Hardware
3. Rust/Corrosion
4. Heaters
5. Lights
6. SF_6 Gas Pressure

Notes

Relays OK
1. Targets
2. Alarms

Notes

Additional Notes

Appendix 4: Substation Gas (SF6) Circuit Breaker Monthly Inspection Form

Substation:
Date:
Inspector:

Inspection Type:	Visual Inspection
Equipment Type:	Gas SF_6 Breaker
Equipment Number:	
Equipment Position:	
Manufacturer:	
Model:	
Serial Number:	
Mfg Date:	

	Visual Assessment New Value	Visual Assessment Last Value	
Bushing Porcelain Condition			Assessment Values
HV Ground Connection			1 - No signs of damage or wear
Operating Mechanism			2 - Minor signs of wear typical for equipment
Spring Charged-Hyd/Air Pressure			3 - Signs of wear scheduled maintenance required
Lights			4 - Visible damage maintenance required immediately
Heaters			
SEL 2411			
Hydraulic/Air Leaks			
Loose Bolts			
Corrosion			

	Recorded Data New Value	Recorded Data Last Value	Units
Gas Pressure Phase A			PSI
Gas Pressure Phase B			PSI
Gas Pressure Phase C			PSI
Counter Operations			
Non-Fault Operations to Subtract			
Actual Operations Since Last Reading			
Counter Phase A			
Counter Phase B			
Counter Phase C			
ETM Motor Phase A			
ETM Motor Phase B			
ETM Motor Phase C			
Comp Hrs/Motor Starts Phase A			Hours/Start
Comp Hrs/Motor Starts Phase B			Hours/Start
Comp Hrs/Motor Starts Phase C			Hours/Start

Additonal Comments

Appendix 5: Substation Gas (SF6) Circuit Breaker 5-Year Inspection Form

Substation:
Date:
Inspector:

Inspection Type:	5-Year
Equipment Type:	Gas SF_6 Breaker
Equipment Number:	
Equipment Position:	
Manufacturer:	
Model:	
Serial Number:	
Mfg Date:	

Visual Assessment	New Value	Last Value	
Bushing Porcelain Condition			Assessment Values
HV Ground Connection			1 - No signs of damage or wear
Operating Mechanism			2 - Minor signs of wear typical for equipment
Spring Charged-Hyd/Air Pressure			3 - Signs of wear scheduled maintenance required
Lights			4 - Visible damage maintenance required immediately
Heaters			
SEL 2411			
Hydraulic/Air Leaks			
Loose Bolts			
Corrosion			

Recorded Data	New Value	Last Value	Units
Gas Pressure Phase A			PSI
Gas Pressure Phase B			PSI
Gas Pressure Phase C			PSI
Counter Operations			
Non-Fault Operations to Subtract			
Actual Operations Since Last Reading			
Counter Phase A			
Counter Phase B			
Counter Phase C			
ETM Motor Phase A			
ETM Motor Phase B			
ETM Motor Phase C			
Comp Hrs/Motor Starts Phase A			Hours/Start
Comp Hrs/Motor Starts Phase B			Hours/Start
Comp Hrs/Motor Starts Phase C			Hours/Start
Power Factor Test			
Insulation Resistance Test Pole 1			
Insulation Resistance Test Pole 2			
Insulation Resistance Test Pole 3			
Pole Contact Resistance Test Pole 1			
Pole Contact Resistance Test Pole 2			
Pole Contact Resistance Test Pole 3			
Total Travel Pole 1			mm
Total Travel Pole 2			mm
Total Travel Pole 3			mm

Appendix 5: Substation Gas (SF_6) Circuit Breaker 5-Year Inspection Form

Recorded Data	New Value	Last Value	Units	
Reaction Time Pole 1			ms	
Reaction Time Pole 2			ms	
Reaction Time Pole 3			ms	
Mechanism Time Pole 1			ms	
Mechanism Time Pole 2			ms	
Mechanism Time Pole 3			ms	
Contact Velocity Pole 1			m/s	
Contact Velocity Pole 2			m/s	
Contact Velocity Pole 3			m/s	
SF_6 Pressure			psig	At 68°F
SF_6 Gas Filing Pressure and Filling Temp Pole 1			psig	Filling temperature
SF_6 Gas Filing Pressure and Filling Temp Pole 2			psig	
SF_6 Gas Filing Pressure and Filling Temp Pole 3			psig	
SF_6 Gas Moisture Content Pole 1			ppmV	At temperature
SF_6 Gas Moisture Content Pole 2			ppmV	At temperature
SF_6 Gas Moisture Content Pole 3			ppmV	At temperature

Preventative Maintenance Tasks Completed	
General Maintenance	
Power Factor Test	
Insulation Resistance Tests	
Pole Resistance Tests	
Check Bushing Hardware Tightness	
Check Tank Hardware Tightness	
Check Rupture Disk Hardware Tightness	
Clean Entrance Bushings if Dirty	
Check Bushing Insulators for Cracks	
Touch-up Chipped Paint on Frame	
Check Anti-Pumping Circuit	
Check Control Cab. Anti-Cond. Heaters	
Check Breaker Tank Heaters	
Check Alarms and Lock-outs	
Operating Mechanism Maintenance	
Verify Mechanism Limit Switch Settings	
Check Charging Motor Brushes	
Check Auxiliary Switch for Proper Adjustment	
Check Mechanism Mounting Hardware Tightness	
Clean and Lubricate Linkages	
Confirm Mechanism Operation with a Test Operation	
Perform Mech. Travel Analysis during Test Operation	
SF_6 Testing	
Leak Check all Flanges, Fittings, and Gas Seals	
Check SF_6 Gas Density	
Check SF_6 Gas Density Monitor for Correctness	
Check Moisture Content of SF_6 Gas	
Trip/Control Circuit Testing	
Perform a Trip Test	
Verify Trip Coil can Operate the Breaker	

Appendix 6: Substation Gas (SF6) Circuit Breaker Typical Inspection Value Ranges

The following Typical Inspection Value Ranges provide an early indicator to a potential malfunction that can lead to equipment failure. The need for additional corrective action or more frequent inspections will be assessed by the Maintenance Manager.

General Maintenance

Power Factor Test

Perform power-factor tests on each pole with the breaker open and on each phase with breaker closed. Perform power-factor or dissipation-factor tests on each bushing equipped with a power-factor/capacitance tap.

Power-factor test values should be within ten percent of nameplate rating for bushings.

Compare tested values with those collected during commissioning and from prior tests. If there are abnormalities, perform further investigation and contact the manufacturer.

Insulation-Resistance Tests

Compare tested values with those collected during commissioning and from prior tests. If there are abnormalities, perform further investigation and contact the manufacturer.

Pole (Contact) Resistance Tests

Using a micro-ohmmeter (or mV drop meter), perform a contact resistance (or mV drop) measurement on each pole of the breaker. The maximum resistance from bushing terminal to bushing terminal should not exceed 120 μΩ.

Mechanism Maintenance

Timing Test

Compare tested values with those collected during commissioning, prior tests, and on-line continuous monitoring. If there are abnormalities, perform further investigation and contact the manufacturer.

Gas (SF_6) Maintenance

Gas Density Levels

If gas pressure drops to 76 psig (0.52 MPa) at 68°F (20°C) – low gas density alarm point.

If the gas pressure drops below 72 psig (0.50 MPa) at 68°F (20°C) – alarm and lockout the breaker. At this level the breaker is unable to maintain the full interrupting rating.

Appendix 6: Substation Gas (SF_6) Circuit Breaker Typical Inspection Value Ranges

Moisture Content Levels

If the moisture content of the SF_6 gas exceed 200 ppm for three (3) or more days after gas filling, the SF_6 gas must be reclaimed and recycled through a drying filter. Before refilling, the circuit breaker must be evacuated to eliminate moisture.

Trip/Control Circuitry

The values of the Trip/Control Circuitry Test should be evaluated based on the requirements of NERC PRC-005.

Appendix 7: Substation Transformer / Shunt Reactor Monthly Inspection Form

Substation:
Date:
Inspector:

Inspection Type:	Visual Inspection
Equipment Type:	Transformer / Reactor (singe phase)
Equipment Number:	
Equipment Position:	
Manufacturer:	
Model:	
Serial Number:	
Mfg Date:	

Visual Assessment	New Value	Last Value	
Bushing Porcelain Condition			Assessment Values
Bushing Oil Level			1 - No signs of damage or wear
HV Ground Connection			2 - Minor signs of wear typical for equipment
Oil Level			3 - Signs of wear scheduled maintenance required
Oil Leaks			4 - Visible damage maintenance required immediately
Radiator Cooling			
SEL 2411			
Gauges and Indicators			
Loose Bolts			
Corrosion			

Recorded Data	New Value	Last Value	Units
Current Top Oil Temp			°F
Peak Top Oil Temp			°F
Current LV Winding Temp			°F
Peak LV Winding Temp			°F
Present HV Winding Temp			°F
Peak HV Winding Temp			°F
Nitrogen Cylinder Pressure (if applicable)			
LTC Counter (If applicable)			
LTC Position Max (if applicable)			
LTC Position Min (if applicable)			
LTC Oil Level (if applicable)			
LTC Filter Gauge Pressure (if applicable)			

Additonal Comments

Appendix 8: Substation Transformer / Shunt Reactor 5-Year Inspection Form

Substation:
Date:
Inspector:

Inspection Type:	5-Year
Equipment Type:	Transformer / Reactor (singe phase)
Equipment Number:	
Equipment Position:	
Manufacturer:	
Model:	
Serial Number:	
Mfg Date:	

Visual Assessment	New Value	Last Value	
Bushing Porcelain Condition			Assessment Values 1 - No signs of damage or wear 2 - Minor signs of wear typical for equipment 3 - Signs of wear scheduled maintenance required 4 - Visible damage maintenance required immediately
HV Ground Connection			
Operating Mechanism			
Spring Charged-Hyd/Air Pressure			
Lights			
Heaters			
SEL 2411			
Hydraulic/Air Leaks			
Loose Bolts			
Corrosion			

Recorded Data	New Value	Last Value	Units
Current Top Oil Temp			°F
Peak Top Oil Temp			°F
Current LV Winding Temp			°F
Peak LV Winding Temp			°F
Present HV Winding Temp			°F
Peak HV Winding Temp			°F
Nitrogen Cylinder Pressure (if applicable)			PSI
LTC Counter (If applicable)			
LTC Position Max (if applicable)			
LTC Position Min (if applicable)			
LTC Oil Level (if applicable)			
LTC Filter Gauge Pressure (if applicable)			

Appendix 8: Substation Transformer / Shunt Reactor 5-Year Inspection Form

Preventative Maintenance Tasks	Completed	
General Maintenance		
Power Factor Test on the windings		
Power Factor Test on the bushings		
Power Factor Test on the arrestors		
Winding Resistivity Test		
Winding Insulation Resistance Test		
Turns Ratio Test		
Cooling Fan, Motor, and Control Systems Test		
Check Operation of Relays (Rapid Pressure Rise, etc.)		
Check Gauges and Indicators		
Touch-up Chipped Paint on Frame		
Insulating Oil Tests		
Moisture Content		
Dielectric Strength Breakdown Voltage		
Oil Power Factor Test		
Oil Resistivity		
Acid Value Test		

Additonal Comments

Appendix 9: Substation Transformer / Shunt Reactor Typical Inspection Value Ranges

The following Typical Inspection Value Ranges provide an early indicator to a potential malfunction that can lead to equipment failure. The need for additional corrective action or more frequent inspections will be assessed by the Maintenance Manager.

Insulating Oil

Dissolved Gas Analysis (DGA) Test

LS Power Grid utilizes IEEE C57.104 – Guide for the Interpretation of Gases Generated in Oil-Immersed Transformers as guidance for the DGA on both transformers and shunt reactors. The status condition based on sampled dissolved gas levels utilize the following tables:

Status	Dissolved key gas concentration limits [µL/L (ppm)[a]]							
	Hydrogen (H_2)	Methane (CH_4)	Acetylene (C_2H_2)	Ethylene (C_2H_4)	Ethane (C_2H_6)	Carbon monoxide (CO)	Carbon dioxide (CO_2)	TDCG[b]
Condition 1	100	120	1	50	65	350	2 500	720
Condition 2	101–700	121–400	2–9	51–100	66–100	351–570	2 500–4 000	721–1920
Condition 3	701–1800	401–1000	10–35	101–200	101–150	571–1400	4 001–10 000	1921–4630
Condition 4	>1800	>1000	>35	>200	>150	>1400	>10 000	>4630

NOTE 1—Table 1 assumes that no previous tests on the transformer for dissolved gas analysis have been made or that no recent history exists. If a previous analysis exists, it should be reviewed to determine if the situation is stable or unstable. Refer to 6.5.2 for appropriate action(s) to be taken.

NOTE 2—An ASTM round-robin indicated variability in gas analysis between labs. This should be considered when having gas analysis made by different labs.

[a] The numbers shown in Table 1 are in parts of gas per million parts of oil [µL/L (ppm)] volumetrically and are based on a large power transformer with several thousand gallons of oil. With a smaller oil volume, the same volume of gas will give a higher gas concentration. Small distribution transformers and voltage regulators may contain combustible gases because of the operation of internal expulsion fuses or load break switches. The status codes in Table 1 are also not applicable to other apparatus in which load break switches operate under oil.

[b] The TDCG value does not include CO_2, which is not a combustible gas.

The results shall be compared with previously collected data to determine any trends in the dissolved gas levels between sampling periods. The following table provides operating procedures based on each condition.

Appendix 9: Substation Transformer / Shunt Reactor Typical Inspection Value Ranges

	TDCG levels (µL/L)	TDCG rate (µL/L/day)	Sampling intervals and operating procedures for gas generation rates	
			Sampling interval	Operating procedures
Condition 4	>4630	>30	Daily	Consider removal from service. Advise manufacturer.
		10 to 30	Daily	
		<10	Weekly	Exercise extreme caution. Analyze for individual gases. Plan outage. Advise manufacturer.
Condition 3	1921 to 4630	>30	Weekly	Exercise extreme caution. Analyze for individual gases. Plan outage. Advise manufacturer.
		10 to 30	Weekly	
		<10	Monthly	
Condition 2	721 to 1920	>30	Monthly	Exercise caution. Analyze for individual gases. Determine load dependence.
		10 to 30	Monthly	
		<10	Quarterly	
Condition 1	≤720	>30	Monthly	Exercise caution. Analyze for individual gases. Determine load dependence.
		10 to 30	Quarterly	Continue normal operation.
		<10	Annual	

Other Insulating Oil Tests

For insulating oil tests other than dissolved gas analysis, LS Power Grid uses predictive maintenance trigger levels set forth in IEEE C57.106 – Guide for Acceptance and Maintenance of Insulating Oil in Equipment for the following tests:

- Moisture content of oil test
- Acid value test
- Dielectric strength breakdown voltage (BDK) test trigger levels
- Oil power factor test

The following table provide minimum values for each test and method:

Appendix 9: Substation Transformer / Shunt Reactor Typical Inspection Value Ranges

Test and method	Value for voltage class		
	≤69 kV	>69 – <230 kV	230 kV and above
Dielectric strength ASTM D1816 kV minimum 1 mm gap[a, c] 2 mm gap[a, c]	 23 40	 28 47	 30 50
Dissipation factor (power factor) ASTM D924 25 ° C, % maximum[c] 100 ° C, % maximum[c]	 0.5 5.0	 0.5 5.0	 0.5 5.0
Interfacial tension ASTM D971 mN/m minimum[c]	25	30	32
Neutralization number (acidity) ASTM D974 mg KOH/g maximum[c]	0.20	0.15	0.10
Water content ASTM D1533 mg/kg maximum (ppm)[b, c]	35	25	20
Oxidation inhibitor content ASTM D2668 Type II oil[c]	0.09% minimum, if in original oil.		

[a]Alternative measurements of 1.0 mm (0.04 in) and 2.0 mm (0.08 in), respectively, for gaps.
[b]The ppm moisture values shown are based on consensus, which are also given in IEEE Std 637. These values should not be used to infer solid insulation dryness or dielectric integrity. The moisture in oil at a given time cannot be related to insulation moisture caused by nonequilibrium conditions. From a dielectric strength point of view, the moisture in oil limits given could be excessive at low temperatures because of high moisture in oil percent saturation levels. See 4.5. However, in operating units, the same moisture in oil levels might represent low moisture in oil percent saturation levels caused by increased oil temperatures.
[c]Any significant changes from previous test data should be investigated.

Oil Resistivity Test

Replace the transformer / shunt reactor oil is the resistivity is ≤ 10^{13} Ω-cm.

Appendix 9: Substation Transformer / Shunt Reactor Typical Inspection Value Ranges

Complete Transformer / Shunt Reactor Inspection and Testing

Winding Power Factor Test

Tested values shall be compared with those collected during commissioning and from prior tests. If there are abnormalities, perform further investigation including consultation with the manufacturer.

Bushing Power Factor Test

A bushing power factor greater than 0.7% shall trigger an investigation and recommendation to replace the oil.

Winding Resistance Test

Temperature corrected winding resistance values should be within 1% of previous results. If there are abnormalities, perform further investigation including consultation with the manufacturer.

Winding Insulation Resistance Test

Tested values shall be compared with those collected during commissioning and from prior tests. If there are abnormalities, perform further investigation including consultation with the manufacturer.

Turns Ratio Test

Results should not deviate by more than 0.5% from either of the adjacent coils or the calculated ratio. Compare tested values with those collected during commissioning and from prior tests. If there are abnormalities, perform further investigation including consultation with the manufacturer.

Appendix 10: Substation Series Compensation System Monthly Inspection Form

Substation:
Date:
Inspector:

Inspection Type:	Visual Inspection
Equipment Type:	Series Compensation
Equipment Number:	
Equipment Position:	
Manufacturer:	
Model:	
Serial Number:	
Mfg Date:	

	Visual Assessment		
	New Value	**Last Value**	
General Inspections			Assessment Values
Check Wires and Electrical Connections			1 - No signs of damage or wear
Corrosion			2 - Minor signs of wear typical for equipment
Check Oil Leaks			3 - Signs of wear scheduled maintenance required
Loose Bolts			4 - Visible damage maintenance required immediately
Inspect Isolators			
Metal Oxide Varistor			
Check Electrical Connections			
Check Porcelain Condition			
Damping Reactor & Resistor			
Check Isolators			
Check for Resin			
Triggered Air-Gap			
Check Enclosure			
Check Electrodes			
Check Bolt Tightness			
Check MOV			
Check Louvers			
Check Plasma Injector			
Check High Voltage Cables			
Check High Voltage Bushings			

Additional Comments

Appendix 11: Substation Series Compensation System Annual Inspection Form

Substation:
Date:
Inspector:

Inspection Type:	Annual
Equipment Type:	Series Compensation
Equipment Number:	
Equipment Position:	
Manufacturer:	
Model:	
Serial Number:	
Mfg Date:	

Visual Assessment	**Completed**
Perform Random Torque Verification	
Measure a Sample of Individual Capacitor Capacitance	
MOV Radom Torque Verification	
Triggered Air-Gap	
Random Torque Verification	
Verify Gap Settings and Adjust as Necessary	
Perform Trigger Circuit and Plasma Injector Test +10kV	
Perform Trigger Circuit and Plasma Injector Test -10kV	
Perform Trigger Circuit and Plasma Injector Current Injection Test	

Recorded Data	**New Value**	**Last Value**	**Units**
Damping Reactor & Resistor			
DC Winding Resistance			Ω
Inductance			H
Triggered Air-Gap			
Measure Capacitor Capacitance			F
Measure VAP Energy			mC
Measure VAP Energy			V
Measure VAP Current			A
Counter			

Additional Comments

Appendix 12: Substation Battery/Charger Monthly Inspection Form

Substation:
Date:
Inspector:

Battery Bank #1

Type: _____
Manufacturer: _____

Battery Room Temp: _____ ° F **Bank Voltage:** _____ V
Charger Float Voltage: _____ Volts **# of cells** 60
Charger Float Amps: _____ Amps

Verify all water levels are between the Max and Min lines: _____
Eye wash station fluid expired (Yes/No): _____
Verify any corrosion present is cleaned: _____

Record the following for all pilot cells:

Cell #	Volts	Hydrometer Reading	Electrolyte Temperature	Corrected Reading
8				
18				
28				
38				
48				
58				

Battery Bank #2

Type: _____
Manufacturer: _____

Battery Room Temp: _____ ° F **Bank Voltage:** _____ V
Charger Float Voltage: _____ Volts **# of cells** 60
Charger Float Amps: _____ Amps

Verify all water levels are between the Max and Min lines: _____
Eye wash station fluid expired (Yes/No): _____
Verify any corrosion present is cleaned: _____

Record the following for all pilot cells:

Cell #	Volts	Hydrometer Reading	Electrolyte Temperature	Corrected Reading
8				
18				
28				
38				
48				
58				

Comments:

S.G +- .001 depending on temp.

For every 3°F > 77°F, subtract 1 point (.001) from hydrometer reading.

For every 3°F < 77°F, add 1 point (.001) to hydrometer reading.

Appendix 13: STATCOM Maintenance Outline Annual Preventative Maintenance Scope

Equipment	Activity	Monthly	Annual	Other Frequency	Outage Required
HVAC	Visual inspection that there is no damage or abnormal condition	Owner	Siemens		No
	Check air condition functioning	Owner	Siemens		No
	Inspect Belts and replace as needed		Siemens		No
	Align Motor as needed		Siemens		No
	Cycle VFD and Dampers		Siemens		No
	Clean air condition filter	Owner	Siemens		No
Building	Test fire detection system		Siemens		Yes
	Test Fire protection system (if installed)		Siemens		Yes
	Inspect fire caulking for damage	Owner	Siemens		No
	Operate door hardware and closers. Cycle each door two times	Owner	Siemens		No
	Note exterior finish condition. Take pictures of any damage that has occurred over annum	Owner	Siemens		No
	Inventory lights for operation. Provide replacement list to Owner	Owner	Siemens		No
	Inspect fire extinguishers annually for pressure		Siemens		No
Thermo-vision	HV / MV Equipment (reactors, capacitors, transformers, etc.)		Siemens	2 weeks prior to outage	No
Busbar Arrangement	Inspect electrical connections for overheating points- Thermography		Siemens		No
	Inspect mechanical connections for loose connections		Siemens	2 Years	Yes
	Check for contamination		Siemens		Yes
	Surface cleaning		Siemens		Yes

	(Bushings, isolators etc.), depending on contamination also more frequently			6 Years	
Surge Arresters	Check that there is no crack or damage on the resin surface		Siemens		Yes
	Inspect electrical connections for overheating points		Siemens		Yes
	Inspect mechanical connections for loose connections		Siemens		Yes
	Check counter, if applicable		Siemens		Yes
	Check indicator, if applicable		Siemens		Yes
	Check contamination		Siemens		Yes
	Surface cleaning, depending on contamination also more frequently		Siemens	6 Years	Yes
Instrument Transformers	Check that there is no crack or damage		Siemens		Yes
	Inspect electrical connections for overheating points Owner)		Siemens		Yes
	Inspect mechanical connections for loose connections Owner)		Siemens		Yes
	Check mechanical connections for loose connection		Siemens		Yes
	Check secondary terminal box		Siemens		Yes
	Check contamination		Siemens		Yes
	Surface cleaning, depending on contamination also more frequently		Siemens	6 Years	Yes
Circuit Breakers	Visual inspection that there is no crack or damage		Siemens		Yes
	Check SF6 pressure at manometer		Siemens		Yes
	Check number of operation cycles		Siemens		No

	Inspect electrical connections for overheating points		Siemens		Yes
	Inspect mechanical connections for loose connections		Siemens		Yes
	Check contamination		Siemens		Yes
	Surface cleaning, depending on contamination also more frequently		Siemens	6 Years	Yes
	Inspection after 12 years or 3000 operations		Siemens	12 Years	Yes
Disconnect Switches	Check that there is no crack or damage		Siemens		Yes
	Inspect electrical connections for overheating points		Siemens		Yes
	Inspect mechanical connections for loose connections		Siemens		Yes
	Check contacts, wear and tear		Siemens		Yes
	Check position of feedback signals		Siemens	6 Years	No
	Check terminal box		Siemens		Yes
	Check contamination		Siemens		Yes
	Surface cleaning, depending on contamination also more frequently		Siemens	6 Years	Yes
Grounding Switches	Check that there is no crack or damage		Siemens		Yes
	Inspect electrical connections for overheating points		Siemens		Yes
	Inspect mechanical connections for loose connections Owner)		Siemens		Yes
	Check contacts, wear and tear		Siemens		Yes
	Check terminal box		Siemens		Yes
	Check contamination		Siemens		Yes
	Surface cleaning,		Siemens		Yes

	depending on contaminationalso more frequently			6 Years	
Surge Capacitors	Visual inspection that there is no crack or leakage		Siemens		Yes
	Check for leakage		Siemens		No
	Checkfor blown fuses (for external fused banks only)		Siemens		Yes
	Inspectelectrical connections for overheating points		Siemens		Yes
	Inspect mechanical connections for loose connections		Siemens	2 Years	Yes
	Measure capacitance		Siemens		Yes
	Check contamination		Siemens		Yes
	Surface cleaning, depending on contaminationalso more frequently		Siemens	6 Years	Yes
Reactors	Check that there is no crack or damage		Siemens		Yes
	Inspectelectrical connections for overheating points		Siemens		Yes
	Inspect mechanical connections for loose connections		Siemens	2 Years	Yes
	check contamination		Siemens		Yes
	Annual Inspection per the reactorsupplier manual		Siemens		Yes
	Surface cleaning, depending on contaminationalso more frequently		Siemens	6 Years	Yes
VSC Module	General visual inspection for cracks, damages, overheating points orleaks	Owner	Siemens		No
	Visual inspection of IGBT module		Siemens		Yes
	Annual Inspection per the VSC module supplier manual		Siemens		Yes
	cleaningof insulators		Siemens		Yes

	damageor abnormal vibration				
	Inspect mechanical connections for loose connections		Siemens	2 Years	Yes
	Inspectionaccording transformer manual		Siemens		Yes
	Take oil sample – or DGA Analysis		Siemens		Yes
	Check for abnormal noisy operation of the pumps and fans	Owner	Siemens		No
	Check for leakage	Owner	Siemens		No
	Full electrical testing		Siemens	6 Years	
Cooling System	Check conductivity level in the maincircuit	Owner	Siemens		No
	Check conductivity level in the ion exchanger circuit	Owner	Siemens		No
	Check the water pressure	Owner	Siemens		No
	Check the makeup water level	Owner	Siemens		No
	Check thatno LED's at the controller doorare flashing	Owner	Siemens		No
	Clean re-cooler		Siemens		Yes
	Inspectionaccording Valve Cooling System Manual		Siemens		Yes
	Change SIMATIC Controller 3,6V lithium battery		Siemens	3 Years	Yes
	Changede-ionized water in refill buffer tanks		Siemens		No
	Change glycol in refill buffer tank		Siemens		No
	Change de-ionizer		Siemens		No
	Checkair intake filters, if applicable		Siemens		No
STATCOM Control System	Visual inspection of cubicles		Siemens		Yes
	Clean inside ofcubicle if required		Siemens		Yes
	Visual Check of terminalsfor loose connections		Siemens		Yes
	Check fans of SIMATIC TDC rack for abnormalnoise		Siemens		No

	Change SIMATIC TDC backup battery		Siemens	3 Years	Yes
HMI System	Check printer ink and paper supply	Owner	Siemens		No
	Clean air intakefan and filters, if applicable		Siemens		Yes
DFR System	Clean air intakefan and filters, if applicable		Siemens		Yes
	Change PC BIOS backup battery		Siemens	4 Years	Yes
Protection	Visual inspection	Owner	Siemens		Yes
	Readout of operational values of each relay and comparison with the actual values to check the analog interfaces.		Siemens		No
AC/ DC Systems	Visual inspection for crack or damage	Owner			No
	Visual inspection of terminals and plug connection		Siemens		No
	Check AC distribution voltage and current indication		Siemens		Yes
	Check DC distribution voltage and current indication		Siemens		Yes
	Check DC Ground Fault Detection functioning		Siemens		Yes