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Code of maintenance for electrochemical energy storage station

电化学储能电站检修规程

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1 Scope

This document specifies the items, methods and quality requirements for battery arrays, power conversion systems, monitoring and control systems and auxiliary facilities of the electrochemical energy storage station.

This document is applicable to electrochemical energy storage stations – with a power of 500 kW and an energy of 500 kW·h and above – that use lithium ion batteries, lead-carbon batteries, flow batteries, and fuel cells as energy storage carriers. It also applies as a reference to other electrochemical energy storage stations.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the version corresponding to that date is applicable to this document; for undated references, the latest version (including all amendments) is applicable to this document.

GB/T 1094.6, Power transformers - Part 6: Reactors

GB/T 1094.11, Power transformers - Part 11: Dry-type transformers

GB 4962, Technical safety regulation for gaseous hydrogen use

GB/T 12706 (all parts), Power cables with extruded insulation and their accessories for rated voltages from 1 kV (U_m = 1.2 kV) up to 35 kV (U_m = 40.5 kV)

GB/T 17702, Capacitors for power electronics

GB/T 20840.2, Instrument transformers - Part 2: Additional requirements for current transformers

GB/T 20840.3, Instrument transformers - Part 3: Additional requirements for inductive voltage transformers

GB/T 24499, Technology glossary for gaseous hydrogen, hydrogen energy and hydrogen energy system

GB 32311, Minimum allowable values of energy efficiency and energy efficiency grades for hydrogen producing systems by water electrolysis

3 Terms and definitions

Terms and definitions determined by DL/T 2528 and GB/T 24499 are applicable to this document.

4 General requirements

4.1 Before the maintenance of the electrochemical energy storage station, a maintenance schedule shall be formulated; also, a maintenance plan and an emergency plan shall be compiled.

4.2 The maintenance of the electrochemical energy storage station includes scheduled maintenance and troubleshooting; also, a condition-based maintenance should be carried out according to the operation of the equipment. The cycle of scheduled maintenance – which should be 1 year – can be adjusted according to the assessment results. The condition-based maintenance should be determined according to the comprehensive assessment results of equipment operating status, fault location, fault type and severity based on operating data.

4.3 The maintenance operation shall be carried out in the aspects of appearance inspection, inspection test, repair, post-repair test, etc. in combining with equipment status. An overall performance test of the energy storage system shall be carried out after the replacement of main components such as battery arrays, power conversion systems, and monitoring and control systems.

4.4 The maintenance of primary equipment such as voltage transformers, switches, surge arresters, and transformers shall be carried out in accordance with the provisions of DL/T 573, DL/T 727, DL/T 1686, DL/T 1689, DL/T 1700, and DL/T 1702; the maintenance of secondary equipment such as AC-DC system for station, relay protection and automation, and metering shall be carried out in accordance with the regulations of DL/T 724, DL/T 995, and DL/T 1664.

4.5 Maintenance personnel shall be trained regularly to be familiar with the design requirements, running conditions and equipment technical requirements of the power station, and to master the maintenance skills and quality requirements of the power station equipment.

4.6 Maintenance tools and appliances shall be inspected and calibrated regularly, and used within the inspection and calibration date.

4.7 Maintenance personnel shall prepare spare parts in advance according to the maintenance schedule and order cycle time.

4.8 The maintenance safety of the electrochemical energy storage station shall meet the requirements of GB/T 42288.

4.9 The electrochemical energy storage station shall formulate environmental protection measures during the maintenance process. Waste batteries and electrolytes shall be recycled.

4.10 After the maintenance is completed, a maintenance assessment of the energy storage station shall be carried out, and a maintenance report shall be compiled.

5 Maintenance of battery arrays

5.1 General provisions

5.1.1 Before the maintenance of battery arrays, the primary circuit AC/DC circuit breaker and isolating switch shall be disconnected, a grounding wire shall be installed on the AC side of the power conversion system, and a safety warning sign shall be hung.

5.1.2 During battery maintenance, the positive and negative poles of battery cells, battery modules, battery clusters, and stacks shall not be short-circuited or reversed.

5.1.3 After the maintenance of lithium ion batteries, lead-carbon batteries, flow batteries and fuel cell arrays, the total voltage balance among battery clusters of the same battery array should be adjusted. The total voltage range between lithium ion battery and lead-carbon battery clusters shall not be greater than 2% of the average value; the total voltage range between flow battery clusters shall not be greater than 4% of the average value; the total voltage range between fuel cell clusters shall not be greater than 5% of the rated value.

5.2 Maintenance of lithium ion battery arrays

5.2.1 Appearance inspection

5.2.1.1 Check the appearance of the battery module, including deformation, cracking, leakage, corrosion and tightness of electrical connections.

5.2.1.2 Check the deformation, damage, corrosion of the battery bracket and the tightness of connection of the grounding wire.

5.2.1.3 Check the air-cooling system of the battery array, including fan rotation and abnormal noise.

5.2.1.4 Check the liquid cooling system of the battery array, including liquid cooling system liquid level, temperature, circulating pump rotation, flow rate, abnormal noise, liquid cooling system circulating pump, pipes, valves, flange connection circuit leakage, damage, cracking and valve switch.

5.2.1.5 Check the connection tightness of power lines and communication lines of the battery management system, as well as the working voltage of the battery management system, and the display of the work indicating lamp.

5.2.3.5 Before replacing battery cells and modules, new battery cells and modules shall be tested for voltage and insulation resistance, where the test results shall meet the requirements of GB/T 36276.

5.2.3.6 When the voltage and temperature data of battery cells and modules is abnormal, the battery cell or battery module shall be replaced.

5.2.3.7 If the charge and discharge energy of the lithium ion battery energy storage system does not meet the requirements of GB/T 36558, and the battery voltage range after offline equalization does not meet the requirements, the battery modules in the same battery array shall be replaced by those of the same specifications and parameters.

5.2.3.8 The battery holder – which is deformed, damaged or corroded – shall be replaced. The grounding wire shall be tightened or replaced in the case of loose connection or damage.

5.2.3.9 If the insulation resistance of the fan of the battery array air-cooling system is unqualified or the rotation is abnormal, the fan shall be repaired or replaced.

5.2.3.10 When the insulation resistance of the circulating pumps of the battery array liquid cooling system is unqualified, the rotation is abnormal, and the temperature and flow sensors are faulty, the circulating pumps and sensors shall be repaired or replaced with the circulating pumps and sensors of the same specification.

5.2.3.11 In the case of leakage, damage or cracking of circulating pumps, pipelines, valves and flanges of the battery array liquid cooling system, they shall be replaced with circulating pumps, pipelines, valves and flanges of the same specification. When the circulating pump and flange bolts are loose, they shall be tightened. When the position of the valve switch is incorrect or jammed, it shall be adjusted.

5.2.3.12 When the battery voltage, temperature and current sensors of the battery management system fail, the sensors shall be replaced.

5.2.3.13 When the voltage and temperature acquisition lines and communication lines of the battery management system are loose or fall off, the wiring shall be restored; when broken, they shall be replaced.

5.2.3.14 When the measured values of battery voltage, temperature and current of the battery management system are abnormal, the battery management system and sensors shall be repaired or replaced.

5.2.4 Post-repair test

5.2.4.1 After the battery management system is repaired or replaced, the measured values of cell voltage, temperature and current of the battery management system shall be checked, and the protection function simulation test and communication function test shall be carried out.

5.2.4.2 After the cells of the battery array have been balanced offline and replaced, it is advisable to carry out voltage range and temperature range tests of cells within the battery cluster and voltage range tests between battery clusters.

5.2.4.3 After the cells of the battery array have been balanced off-line and replaced, it is advisable to carry out the charge-discharge energy and efficiency tests of the lithium ion battery energy storage system.

5.2.4.4 After the fan of the battery array air-cooling system and the circulating pump of the liquid-cooling system are repaired or replaced, various performance tests shall be carried out.

5.3 Maintenance of lead-carbon battery arrays

5.3.1 Appearance inspection

5.3.1.1 Check the appearance of the battery, including deformation, cracking, acid leakage, liquid leakage, corrosion, safety valve action and electrical connection tightness.

5.3.1.2 Check the battery electrolyte level.

5.3.1.3 Check the deformation, damage, corrosion of the battery bracket and the tightness of connection of the grounding wire.

5.3.1.4 Check the air-cooling system of the battery array, including fan rotation and abnormal noise.

5.3.1.5 Check the connection tightness of power lines and communication lines of the battery management system, as well as the working voltage of the battery management system, and the display of the work indicating lamp.

5.3.1.6 Check the human-machine interface of the battery management system, including the display and refresh of data such as battery voltage, temperature, battery cluster voltage, current and system time, as well as alarm information records.

5.3.2 Inspection test

5.3.2.1 Test the internal resistance of the cell, and verify the corresponding measured values of the battery management system.

5.3.2.2 Verify the cell voltage sensor, temperature sensor and current sensor of the battery management system.

5.3.2.3 Test the battery voltage, temperature and current, and verify the corresponding measured values of the battery management system.

5.3.2.4 Test the voltage range and temperature range of cells in the battery cluster.

5.3.3.11 When the battery voltage, temperature and current sensors of the battery management system fail, the sensors shall be replaced.

5.3.3.12 When the voltage and temperature acquisition lines and communication lines of the battery management system are loose or fall off, the wiring shall be restored; when broken, they shall be replaced.

5.3.3.13 When other abnormalities occur in the battery management system, the battery management system shall be repaired or replaced.

5.3.4 Post-repair test

5.3.4.1 After the battery management system is repaired or replaced, the measured values of battery voltage, temperature and current of the battery management system shall be checked, and the protection function simulation test and communication function test shall be carried out.

5.3.4.2 After the cells of the battery array have been balanced offline and replaced, it is advisable to carry out voltage range and temperature range tests of cells within the battery cluster and voltage range tests between battery clusters.

5.3.4.3 After the cells of the battery array have been balanced off-line and replaced, it is advisable to carry out the charge-discharge energy and efficiency tests of the battery energy storage system.

5.3.4.4 After the fan of the battery array air-cooling system is repaired or replaced, various performance tests shall be carried out.

5.4 Maintenance of flow battery arrays

5.4.1 Appearance inspection

5.4.1.1 Check the deformation, damage, leakage, corrosion and compression bolts, positive and negative connection tightness of the stack.

5.4.1.2 Check the deformation, cracking, leakage, inclination, liquid level indication, etc. of the electrolyte storage tank.

5.4.1.3 Check the deformation, damage, corrosion of the battery holder and the tightness of connection of the grounding wire.

5.4.1.4 Check the electrolyte circulating pump, including rotation, abnormal noise, damage, leakage, etc., and the tightness of bolt connections.

5.4.1.5 Check the pipes, flanges, and valves, including deformation, damage, cracking, leakage, bolt connection tightness, and valve switch conditions.

5.4.1.6 Check the connection tightness of sensors such as voltage, current, temperature, pressure, flow rate and leakage.

5.4.1.7 Check the connection tightness of power lines and communication lines of the battery management system, as well as the working voltage of the battery management system, and the display of the work indicating lamp.

5.4.1.8 Check the human-machine interface of the battery management system, including the display and refresh of data such as electrolyte temperature, stack voltage, battery array current, pressure, flow rate, and system time, as well as alarm information records.

5.4.2 Inspection test

5.4.2.1 Detect the concentration of electrolyte components, the valence state of active substances, and the content of impurity elements.

5.4.2.2 Check the temperature, voltage, current, pressure and flow sensors of the battery management system.

5.4.2.3 Detect the insulation resistance, charging and discharging power of the stack.

5.4.2.4 Detect the insulation resistance and flow rate of the electrolyte circulating pump.

5.4.2.5 Detect the pipeline pressure resistance of the electrolyte circulation system of the flow battery.

5.4.2.6 Detect the electrolyte temperature, stack voltage and battery array current, pressure and flow of the battery management system, and verify the corresponding measured values of the battery management system.

5.4.2.7 Carry out the charge-discharge energy and efficiency test of the flow battery energy storage system, and carry out the calibration of the charge-discharge energy of the energy storage system.

5.4.3 Repair

5.4.3.1 Before repairing, the electrolyte in the repairing part shall be drained.

5.4.3.2 The compression bolts shall be tightened when the stack is not compressed, and shall be fastened when the positive and negative connections are loose.

5.4.3.3 If the stack is deformed, damaged, leaking, corroded, etc., the insulation resistance is less than 1 MΩ, and the rated energy efficiency of the stack is lower than 75%, it shall be repaired or replaced with a stack of the same specifications and parameters. The new stack shall be tested for insulation resistance, stack voltage range, stack efficiency, and electrolyte circuit withstand voltage.

5.5.1 Appearance inspection

5.5.1.1 Check the deformation, damage, leakage, corrosion, displacement of the electrode plate, color of the battery tab, tightness of the compression bolt, and connection of the positive and negative electrodes of the electrolytic cell.

5.5.1.2 Check the deformation, damage, leakage of the stack and the tightness of the positive and negative wiring connections.

5.5.1.3 Check the appearance of the circulating pump, hydrogen compressor, air compressor, and water pump, including deformation, damage, abnormal rotation noise, etc., as well as the tightness of bolt connections and the turbidity and odor of the oil medium.

5.5.1.4 Check the appearance and connection tightness of sensors such as voltage, current, temperature, pressure, liquid level, flow, and hydrogen monitoring.

5.5.1.5 Check the appearance of pipes, flanges, valves and connectors, including deformation, damage, cracking, corrosion, leakage, etc., as well as the tightness of bolt connections and the status of valve switches.

5.5.1.6 Check the appearance of the electrolyzer and stack support frame, including deformation, damage, corrosion and the tightness of the connection of the grounding wire.

5.5.1.7 Check the tightness of the power line and communication line of the fuel cell array automatic control device, the working voltage of the fuel cell array automatic control device, and the display of the working indicator light.

5.5.1.8 Check the human-machine interface of the fuel cell array automatic control device, including the display and refresh of data such as pressure, temperature, voltage, current, flow and system time, and alarm information records.

5.5.2 Inspection test

5.5.2.1 Detect the grounding resistance of hydrogen pipelines and containers.

5.5.2.2 Carry out the airtightness test of the hydrogen production system, hydrogen storage system, fuel cell system and piping.

5.5.2.3 Check the sensors such as voltage, current, temperature, pressure, flow, hydrogen/oxygen content, moisture content, conductivity, etc., as well as thermometers, pressure gauges, and safety valves.

5.5.2.4 Carry out pneumatic and electric valve transmission tests.

5.5.2.5 Carry out the inspection of pressure vessels of hydrogen production system and hydrogen storage system.

5.5.2.6 Detect the outlet water quality of external water supply and pure water system.

5.5.2.7 Detect the cooling water quality of the cooling system.

5.5.2.8 Detect the composition of the electrolyte in the alkaline water electrolyzer.

5.5.2.9 Detect the output voltage, power and capacity of the starting power supply.

5.5.2.10 Carry out the protection function tests of the fuel cell array control system voltage, current, temperature, pressure, liquid level, etc.

5.5.2.11 Carry out control function tests such as start-up and emergency shutdown of the fuel cell array control system and communication function test.

5.5.2.12 Carry out the start/shutdown test of the hydrogen production system, and test the purity of hydrogen and oxygen.

5.5.2.13 Carry out the hydrogen discharge capacity test of the hydrogen storage system.

5.5.2.14 Carry out start/shutdown test and efficiency test of the fuel cell system.

5.5.3 Repair

5.5.3.1 Before repairing, the shut-off valve connected to the repaired part shall be switched off, and the repaired part shall be replaced with nitrogen no less than 3 times. The repair operation shall meet the safety requirements of GB 4962.

5.5.3.2 When the electrolyzer, electric stack pressing bolts, and positive and negative wires are loose, they shall be tightened. If the electrolyzer and electric stack are deformed, damaged, leaked, corroded, plate shifted, the color of the tab is abnormal, or the air tightness test fails, they shall be repaired or replaced.

5.5.3.3 When the rated power and efficiency of the fuel cell stack do not meet the requirements, the stack shall be replaced.

5.5.3.4 When the purity of the hydrogen/oxygen at the outlet of the electrolyzer is unqualified, the electrolyte or the electrolyzer shall be replaced. When the hydrogen purity at the outlet of the hydrogen purification system does not meet the design requirements, the purification system shall be repaired or replaced.

5.5.3.5 When the hydrogen discharge capacity of the hydrogen storage system is lower than 80% of the design capacity, the hydrogen storage alloy container shall be activated. When the hydrogen discharge capacity after activation is still lower than 90% of the design capacity, it shall be repaired or replaced.

5.5.3.6 When the electrolyte of the alkaline water electrolyzer does not meet the requirements of GB/T 37562, the electrolyte shall be replaced.

5.5.4 Post-repair test

5.5.4.1 The hydrogen pipelines and containers, repaired or replaced electrolyzers and stacks shall be tested for air tightness, and the pipelines and containers shall be replaced with hydrogen after the test.

5.5.4.2 The electric and pneumatic valves after repair or replacement shall be tested for transmission.

5.5.4.3 After the fuel cell array control system is repaired, the protection function test, emergency shutdown function test and communication function test shall be carried out.

5.5.4.4 The hydrogen discharge capacity test shall be carried out after the hydrogen storage container of the hydrogen storage system is repaired or replaced.

5.5.4.5 After the water electrolysis hydrogen production system is repaired, the start/shutdown test shall be carried out; after the electrolyzer is replaced, the hydrogen production energy efficiency test shall be carried out according to the test method specified in GB 32311.

5.5.4.6 After the hydrogen storage system or fuel cell system is repaired, the start/shutdown test and efficiency test of the fuel cell system shall be carried out.

6 Maintenance of power conversion system

6.1 General provisions

6.1.1 Before the power conversion system is overhauled, the AC and DC side switches shall be disconnected, and the port residual voltage shall be measured. When the DC port voltage is less than 50 V and the AC port voltage is less than 36 V, the case (door) can be opened for maintenance operation.

6.1.2 During the maintenance of the power conversion system, anti-static measures shall be taken, and energy storage components such as reactors and capacitors shall be fully discharged.

6.1.3 After the overall replacement of the power conversion system or the replacement of important components such as controllers, power modules, capacitors, reactors, and isolation transformers, corresponding functional and performance tests shall be carried out.

6.2 Appearance inspection

6.2.1 Check the appearance of the power conversion system, including deformation, corrosion, damage and the fastening of the ground wire connection.

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