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Reliability Evaluation Methods for Vanadium Flow Battery

全钒液流电池可靠性评价方法

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Reliability Evaluation Methods for Vanadium Flow Battery

1 Scope

This document specifies the overall requirements, evaluation indicators and calculation methods, test requirements and methods, reliability determination, and evaluation result for the reliability evaluation of the vanadium flow battery systems.

This document is applicable to the evaluation of all types of vanadium flow battery systems for indoor or outdoor use.

2 Normative References

The contents of the following documents constitute indispensable clauses of this document through the normative references in the text. In terms of references with a specified date, only versions with a specified date are applicable to this document. In terms of references without a specified date, the latest version (including all the modifications) is applicable to this document.

GB/T 2828.1-2012 Sampling Procedures for Inspection by Attributes - Part 1: Sampling Schemes Indexed by Acceptance Quality Limit (AQL) for Lot-by-lot Inspection

GB/T 29840 Vanadium Flow Battery - Terminology

GB/T 32509-2016 General Specification for Vanadium Flow Battery

GB/T 33339-2016 Vanadium Flow Battery System - Test Method

GB/T 34866 Vanadium Flow Battery - Safety Requirements

ISO/IEC Guide 98-3 Uncertainty of Measurement - Part 3: Guide to the Expression of Uncertainty in Measurement

3 Terms and Definitions

The terms and definitions defined in GB/T 29840 and the following are applicable to this document.

3.1 reliability

The ability of a product to complete specified functions under specified conditions and within a specified time.

3.2 fault

A state, in which, a product is unable to perform its specified functions.

NOTE: this does not apply if the specified functions cannot be performed due to preventive maintenance or other planned actions or lack of external resources.

4 Overall Requirements

4.1 Reliability evaluation indicators shall include rated energy efficiency, capacity retention rate and utilization factor.

4.2 The reliability evaluation method shall adopt sampling test, and after the rated energy efficiency test, capacity retention rate test and utilization factor test, the corresponding indicators can be calculated.

4.3 The evaluation result shall be output in a test report.

5 Evaluation Indicators and Calculation Methods

5.1 Rated Energy Efficiency

The rated energy efficiency of the vanadium flow battery systems shall be the ratio of the net discharge capacity to the sum of the charge capacity plus the auxiliary energy consumption of the charging process in a constant power charge and discharge cycle within the evaluation period. It is calculated in accordance with Formula (1).

$$\eta = \frac{E_{sd} - W_{sd}}{E_{sc} + W_{sc}} \times 100\% \qquad \cdots\cdots (1)$$

Where,

η---the rated energy efficiency of the battery system;

E_{sd}---the discharge watt-hour capacity of the battery system recorded by the measurement instrument, expressed in (W • h);

W_{sd}---the auxiliary energy consumption of the battery system during the discharging process recorded by the measurement instrument, expressed in (W • h);

E_{sc}---the charge watt-hour capacity of the battery system recorded by the measurement instrument, expressed in (W • h);

W_{sc}---the auxiliary energy consumption of the battery system during the charging process recorded by the measurement instrument, expressed in (W • h).

5.2 Capacity Retention Rate

The ratio of the n^{th} net discharge watt-hour capacity of the vanadium flow battery systems within the statistical period to the rated watt-hour capacity, which is calculated in accordance

satisfy the requirements of the converter equipment.

6.5.3 In addition to the tests conducted in accordance with GB/T 33339-2016, other tests may simulate actual operating conditions or use full state-of-charge (SOC) charge and discharge cycles. After each charge / discharge, stop and let it stand. The standing time shall be greater than 10 minutes.

6.6 Measurement Instruments

6.6.1 Voltage measurement

The voltage measurement instrument shall have an accuracy of not lower than Class 0.5 and its internal resistance shall be at least 1 kΩ/V. Other measurement instruments with equivalent accuracy may also be used.

6.6.2 Current measurement

The current measurement instrument shall have an accuracy of not lower than Class 0.5. Other measurement instruments with equivalent accuracy may also be used.

6.6.3 Electric energy measurement

The electric energy measurement instrument shall have an accuracy of not lower than Class 0.5.

6.6.4 Temperature measurement

The division value of the thermometer for temperature measurement shall be not greater than 1 °C, and the calibration accuracy shall be not lower than 0.5 °C.

6.7 Test of Rated Energy Efficiency

6.7.1 A rated energy efficiency test shall be respectively conducted at the beginning of the test period and before the end of the test period. If the test period is relatively long, a rated energy efficiency test shall be conducted once in the middle of the test.

6.7.2 In accordance with the provisions of 8.1.7 in GB/T 33339-2016, carry out the rated energy efficiency test. In addition, in accordance with 5.1, calculate the rated energy efficiency.

6.8 Test of Capacity Retention Rate

6.8.1 A capacity retention rate test shall be respectively conducted at the beginning of the test period and before the end of the test period. If the test period is relatively long, a capacity retention rate test shall be conducted once in the middle of the test.

6.8.2 In accordance with the provisions of 5.7 in GB/T 32509-2016, carry out the capacity retention rate test. In addition, in accordance with 5.2, calculate the capacity retention rate.

6.9 Test of Utilization Factor

6.9.1 The battery systems shall be charged and discharged in accordance with the operating mode agreed upon between the customer and the manufacturer.

6.9.2 Record the duration of the fault state within the test period, calculate the number of fault-free operating hours; in accordance with 5.3, calculate the utilization factor.

7 Reliability Determination

7.1 Reliability Determination of Rated Energy Efficiency

During the evaluation period, the rated energy efficiency of the vanadium flow battery systems shall be not lower than 90% of the nominal value.

7.2 Reliability Determination of Capacity Retention Rate

During the evaluation period, the capacity retention rate of the vanadium flow battery systems shall be not lower than 80% of the nominal value. If necessary, capacity restoration can be performed before the capacity test.

7.3 Reliability Determination of Utilization Factor

The determination is carried out in accordance with the value agreed upon by the customer and the manufacturer.

8 Evaluation Result

The evaluation result is a test report, which shall at least include the following contents.

a) Foreword, explaining the origin of the test task.

b) Test basis.

c) Test purpose.

d) Test object.

e) Environmental conditions.

f) Test equipment and instruments.

g) Test results:

   1) Arrange the original data, which should be expressed in a list;

   2) Calculation results.

h) Conclusions and recommendations.

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