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**Technical specification of power quality measurement
and evaluation for electric vehicle battery
charging/swap station**

电动汽车充换电站电能质量测试评价技术规范

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Technical specification of power quality measurement and evaluation for electric vehicle battery charging/swap station

1 Scope

This Standard specifies the power quality measurement items, measurement methods, measurement results evaluation requirements for electric vehicle battery charging/swap station.

This Standard is applicable to the power quality measurement and evaluation for electric vehicle battery charging/swap station powered by dedicated power grids of 10kV and above. Electric vehicle charging stations or swap stations that are powered by other voltage levels or not powered by the public grid can be implemented by using this Standard as the reference.

2 Normative references

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

GB/T 12325-2008, *Power quality - Deviation of supply voltage*

GB/T 12326-2008, *Power quality - Voltage fluctuation and flicker*

GB/T 14549-1993, *Quality of electric energy supply. Harmonics in public supply network*

GB/T 15543-2008, *Power quality - Three-phase voltage unbalance*

GB/T 17626.30, *Electromagnetic compatibility - Testing and measurement techniques - Power quality measurement methods*

GB/T 19862-2016, *General requirements for monitoring equipment of power quality*

GB/T 24337-2009, *Power quality - Inter-harmonics in public supply network*

GB/T 29316-2012, *Power quality requirements for electric vehicle charging/battery swap infrastructure*

GB/T 29317-2012, *Terminology of electric vehicle charging/battery swap infrastructure*

GB 50966-2014, *Code for design of electric vehicle charging station*

3 Terms and definitions

For the purposes of this document, the terms and definitions defined in GB/T 29317-2012 as well as the followings apply.

3.1 electric vehicle (EV) battery charging station

a place that provides charging services for electric vehicles and consists of three or more electric vehicle charging equipment

[Source: GB/T 29781-2013, 3.4, modified]

3.2 EV battery swap station

a place that provides battery replacement services for electric vehicles and charges power batteries

[Source: GB/T 29317-2012, 5.2, modified]

3.3 rapid voltage change; RVC

the phenomenon of rapid transition of the voltage rms value between two voltage steady states

NOTE 1: The characteristic indexes that characterize the rapid voltage change event include the start time, the end time (duration), the maximum voltage change $\Delta U_{\max}$, and the steady-state voltage change ΔU_{ss} .

NOTE 2: The rapid voltage changes described in this document are limited to voltage changes under steady state conditions and do not involve voltage changes under transient conditions.

NOTE 3: The voltage steady-state is related to the rapid voltage change threshold.

3.4 voltage steady-state

100 consecutive half-cycle voltage rms; slide by half cycle time interval; the average value after sliding does not exceed the threshold range of rapid voltage changes based on the average value before sliding

power grid. The measurement duration shall not be less than 24h.

NOTE: The measurement duration can be adjusted according to the change cycle of the actual load size of the charging station or swap station.

5.4 Data record

The measurement data and its recording interval are as follows:

- a) Supply voltage deviation, harmonics, unbalance, power factor measurement data recording time interval include 1min, 3min, 5min or 10min. It is advisable to use 1min;
- b) The long-term voltage flicker value shall be continuously recorded and stored a set of data every 2h;
- c) For the captured rapid voltage change events, the characteristic values are recorded, including the start time, duration, maximum voltage change $\Delta U_{\max}$ and steady-state voltage change ΔU_{ss} .

5.5 Measurement methods

5.5.1 The measurement methods of power supply voltage deviation, harmonics, inter-harmonics, three-phase unbalance and voltage flicker shall comply with the requirements of GB/T 12325-2008, GB/T 14549-1993, GB/T 24337-2009, GB/T 15543-2008 and GB/T 12326-2008 respectively.

5.5.2 The rapid voltage change measurement method is carried out in accordance with Annex B.

5.5.3 The power factor correlation measurement method is as follows:

- a) For the voltage and current measurement methods in the power factor measurement process, see the power supply voltage class A measurement method in GB/T 17626.30;
- b) Conduct simultaneous calculation of active power, reactive power and power factor.

6 Measurement result evaluation

6.1 Supply voltage deviation

Give the maximum value of positive and negative voltage deviations. Evaluate

whether the measurement results of power supply voltage deviation meet the limit requirements of GB/T 12325-2008.

6.2 Harmonics

Give the total harmonic voltage distortion rate, the 2~50th harmonic voltage content rate, and the 95% probability maximum value of the 2~50th harmonic current. Evaluate whether the harmonic voltage content rate and the measurement results of the harmonic current injected into the power supply point meet the limit requirements of GB/T 14549-1993.

6.3 Inter-harmonics

Give the 95% probability maximum value of the inter-harmonic voltage content rate in the frequency range of 0Hz~800Hz. Evaluate whether it meets the limit requirements of GB/T 24337-2009.

6.4 Three-phase unbalance

Give the three-phase voltage unbalance, 95% probability maximum value and maximum value of negative sequence current. Evaluate whether the three-phase voltage unbalance and the negative sequence current injected into the power supply point meet the limit requirements of GB/T 15543-2008.

6.5 Voltage flicker

Give the maximum value of long-term voltage flicker. Evaluate whether the voltage flicker measurement results meet the limit requirements of GB/T 12326-2008.

6.6 Rapid voltage changes

If a rapid voltage change event is captured, the characteristic index of the rapid voltage change event is given. Analyze the correlation with changes in charging load.

6.7 Power factor

Give the power factor at peak charging load. Evaluate whether the power factor at the peak of the charging load meets the level A equipment limit 0.95 specified in GB/T 29316-2012 or 0.95 specified in GB 50966-2014.

Annex C

(Informative)

A brief introduction to the influence of electric vehicle charging on power quality of power supply points and the countermeasures when it exceeds the standard

C.1 Overview

The change of electric vehicle charging and swap station load presents randomness and diversity. It is closely related to the number of charging vehicles in the region, the type of charging vehicles (residential vehicles or commercial vehicles, etc.), and the charging cycle (working days or holidays) and other factors. Therefore, different types of charging facilities and basic power supply facilities shall be built according to different charging needs. Reasonable matching of different charging strategies can reduce the impact of the charging process on the power supply point of the power grid and promote the coordinated development of electric vehicles and the power grid.

C.2 Impact of electric vehicle charging on power supply point

The influence of electric vehicle charging load on the power supply point is mainly reflected in the increase in the load rate of the upper line and transformer at the power supply point and the power quality exceeding the standard. The increase in the load rate of lines and transformers leads to an increase in the loss of the distribution network. It makes indirect deterioration of power quality indexes. The non-linearity, impact and uncertainty of electric vehicle charging load are easy to cause power quality indexes such as supply voltage and harmonics to exceed the standard. It is easy to cause problems such as voltage harmonic oscillation and voltage mutation and affect the power quality of other users in the surrounding area. To improve the quality of electric vehicle charging power and ensure the coordinated development of electric vehicles and power grids, it needs to start with infrastructure, such as optimal power supply point, increase power supply point transformer and line power supply capacity. It is also necessary to start with the power quality control method and take measures to reduce the impact of power quality.

C.3 Countermeasures for power quality exceeding standard

C.3.1 Supply voltage deviation

The countermeasures for the situation where the power supply voltage deviation exceeds the standard are suggested as follows:

- a) If the deviation of the operating supply voltage of the charging station or the swap station does not meet the requirements of the national standard limit, and the deviation of the background power supply voltage does not exceed the standard, it is advisable to put forward measures to alleviate the problem of voltage deviation exceeding the standard in combination with the change of charging power, especially the change of reactive power (see B.3.6);
- b) If the deviation of the operating power supply voltage of the charging station or the swap station does not meet the requirements of the national standard limit, and the deviation of the power supply voltage of the background power grid also exceeds the standard, voltage control measures shall be taken. If necessary, the power supply lines or power supply transformers shall be expanded and transformed to reduce the impact.

C.3.2 Harmonics and inter-harmonics

The countermeasures for the over-standard harmonics and inter-harmonics are suggested as follows:

- a) If the harmonic voltage, inter-harmonic voltage or injected harmonic current exceeds the standard and the background power grid harmonic voltage or inter-harmonic voltage does not exceed the standard, corresponding harmonic control measures shall be taken at charging and swap stations. Or combine the relationship between harmonics and charging power trend and adopt an orderly charging strategy;
- b) If the harmonic voltage, inter-harmonic voltage or injected harmonic current exceeds the standard and the background power grid harmonic voltage or inter-harmonic voltage also exceeds the standard, the reasons shall be comprehensively analyzed, and corresponding remedial measures shall be taken.

C.3.3 Three-phase unbalance

If the three-phase voltage unbalance and the negative sequence current injected into the power supply point exceed the standard, the charging and auxiliary power loads in the charging and swap stations shall be reasonably arranged according to the balance principle, or corresponding control measures shall be taken.

C.3.4 Voltage flicker

If the voltage flicker exceeds the standard, corresponding voltage control measures shall be taken.

- a) UPQI (avg) represents the normalized average value of each item index at the measurement point.
- b) UPQI (max) represents the normalized maximum value of each item index at the measurement point.
- c) UPQI (node) represents the unified power quality index value of the measurement point. If the measurement point harmonics, voltage flicker and other project indexes are all less than 1 after normalization, the value is the maximum value among the normalized values of each project index. Otherwise, the value is 1 and gradually accumulates the part of each exceeding index value minus 1.
- d) UPQI (system) represents the unified power quality index value of a charging and swap station system. Similar approach to single measurement point: If the UPQI (node) value of each measurement point is less than 1, the value is the maximum index of UPQI (node) in each measurement point. Otherwise, the value is 1 and the remaining value after subtracting 1 from the UPQI (node) value of each exceeding measurement point is gradually accumulated.
- e) UPQI (system/avg) represents the improved unified power quality index value (referred to as the improved value). If the indexes of each point are less than 1, the UPQI (system/avg) is the maximum index of the UPQI (node) value of each measurement point. Otherwise, UPQI (system/avg) is the average of the sum of the remaining values after subtracting 1 from the UPQI (node) value of each over-standard point and the number of nodes.
- f) The power quality comprehensive evaluation index results of system 1 are shown in Table D.5. When the UPQI (avg) results are all qualified, the conclusion of the characterization measurement is wrong and unscientific. When the UPQI (max) index value does not affect the measurement conclusion, but the corresponding measurement point 2 and measurement point 3 are the same, the measurement point 2 has two indexes exceeding the standard, and the measurement point 3 has one index exceeding the standard, it shows that the UPQI (max) index is also unreasonable. The UPQI (node) index value can also consider the comprehensive hazards of different indexes without affecting the measurement conclusion. It has good applicability, so the comprehensive evaluation index of single measurement point power quality shall use UPQI (node) index.

Table D.5 -- Evaluation results of comprehensive indexes of system 1 power quality

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