Quality Analysis and Research of Charging Facilities for Electric Vehicles

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Abstract. With the development of new energy vehicles in recent years charging infrastructure industry is also in rapid development. In this study, to analyze the quality of charging infrastructure in its service life cycle, enterprises of charging facilities were visited and charging stations were researched on-site. This study also analyzed the evaluation system, discussed the limiting factors in the process of charging infrastructure development. In this study, the quality development direction of future charging infrastructure is defined, and data support is provided for the high-quality development of charging infrastructure.

Key words: New energy vehicles; Charging Facilities for Electric Vehicles; Product quality.

1. Current Development Status of Charging Facilities
At present, the AC and DC charging facilities on the public charging infrastructure market are under rapid construction. With the rapid development of supporting industries for electric vehicle manufacturers, more and more AC charging facilities are built in parking lots, which brings the rapid growth of the market demand for AC charging piles. At the same time, with the continuous development of battery technology, the battery can accept more and more charging power, high-power DC charging facilities are also getting more and more attention. As far as the current situation is concerned, the laying of charging infrastructure in China shows diversified development according to different needs.

In terms of public terminals and public transport terminals, DC charging piles with large output power are mainly used. Such charging piles are mainly constructed in the modes of charging operators' self-operation, self-construction by enterprises, self-construction by individuals or co-construction by cooperation. By analyzing the data of newly built DC charging piles over the years, it can be found that the power of the DC charging piles is increasing. In 2016, the DC charging with rated power of 60KW is the main part, and in the past two years, the DC charging with rated power of 80KW, 120KW and 240KW account for a higher proportion of the construction. With the continuous development of high-power charging technology, from 2019, more and more charging operators have begun to deploy high-power charging reactors which has rated power at 480KW or even 640KW. In terms of privately built charging piles, the main features are AC charging piles with low power, high safety and low cost. Such AC charging piles are mainly constructed by electric vehicle manufacturing enterprises. In addition, the exploration of low-power DC charging pile technology in the charging industry in 2019 also provides another new technology option for private charging piles.

The voltage platform of DC charging is divided by 2017. The voltage platform of DC charging put into use before 2017 is mainly 500V, and the dedicated bus station is 750V. Most of the voltage platforms put into use after 2017 are above 750V. From the statistical results, the 750V voltage platform accounted for more than 50% of the research enterprises accounted for about two-thirds.
There are two reasons for this trend. On one hand, with the continuous development of high-power charging technology, the vehicle voltage platform and charging capacity are constantly improving. On the other hand, the technology of the charging infrastructure itself has been improved, and the popularity of the wide-voltage constant power module has accelerated the withdrawal of dc charging piles from the market of the 500V voltage platform.

2. Quality Investigation of Charging Facilities

According to the investigation of enterprises and the visit to charging stations, the common problems encountered in the development of charging infrastructure mainly include display screen, power module, charging interface, auxiliary power supply, power battery, safety protection, standard use, station construction, and standardization. The mainly problem of power module is reliability. Especially under long-term working conditions the cooling system does not maintain an optimal performance, which will cause power module failure. If the maintenance is not timely, it will cause the facility to drop the current when charging. If the current drop is serious, it will directly cause the shutdown. In addition, the noise problem of the power module is also a problem that interferes with the charging operator, because of the large noise there will be more complaints in the crowded place.

The problem of the charging interface is manifested in two aspects, one is the locking and unlocking for the charging interface, the other is the poor durability of the charging interface. First, the current electronic lock usually adopts the pulse electromagnetic locks or motor type electronic lock that push rod or crankshaft was adopted to realize locking and unlocking. The reasons that when the plug does not reach the designated position, interface is not compatible, or the cable is heavy often lead to the charging gun electronic lock gun failure or failure to unlock. In addition, the reliability of electronic and mechanical lock products also causes the problem of locking. At present, the locking strategy of the product is to realize the locking of the connecting device by means of electronic locking and mechanical locking. In the actual station, mechanical lock break such as figure 1, electronic lock failure and other problems make the locking strategy can not be used effectively, which brings some troubles.

![Figure 1](image1.png)

**Figure 1.** Lock damage of charging interface.

The poor durability of the charging interface is mainly reflected that in the field after a period of use its performance appears to decline, excessive temperature, ablation and other phenomena. This kind of ablation will lead to the charging interface cross-infection, resulting in a relatively bad impact. As the life cycle of power output terminal product, charging infrastructure should refer to the life cycle of power equipment, but at the same time, the timely replacement of some consumables and wearing parts in the equipment should be considered. If the charging interface is frequently used, within about 1 year, there will be large wear and tear and interface heating, which will cause great damage to the vehicle pile like figure 2. Some charging interfaces adopt thickening and reinforcing terminal coating
to prolong wear and at the same time monitor the interface temperature in real time to prevent cross-infection and damage to the charging pile and vehicle interface.

![Charging interface ablation.](image)

**Figure 2.** Charging interface ablation.

The auxiliary power supply problem mainly has several aspects. On the one hand, there are still some low-voltage auxiliary power supply of 24V for charging infrastructure in the market. For products with 12V auxiliary power supply, the voltage and current of auxiliary power supply are unstable and jump, resulting in protection of auxiliary source circuit and poor reliability. The problems of safety protection are mainly reflected in short circuit protection, insulation monitoring, personnel protection against electric shock and the balance between compatibility and safety.

During the short-circuit protection, the fuse cannot be fused reliably. In terms of technical scheme, it is more appropriate to give priority to the fuse of ablating charging pile. But there is a problem in actual matching, that is, the I²t of the vehicle pile protection component and the short-circuit tolerance current value of the main circuit cable should be well matched with each other.

Insulation problem. Some models will start insulation monitoring in the charging handshake stage, which will affect the insulation monitoring results of charging piles. In the configuration phase, the current battery pack voltage of some models in the BCP message differs greatly from the voltage outside the charging port. During the start-up stage, there is a voltage or even a negative voltage outside of the charging port. In order to save cost, some automobile companies remove the K5 and K6 contactors, resulting in this problem.

Personnel electric shock protection. According to the current standard, the electric energy stored by the ground capacitance of the charging system in accordance with the safety requirements of human body should not exceed 0.2J. In practice, vehicles often take up too much, leaving too little margin for charging piles. In addition, as the voltage platform of the vehicle is getting higher and higher, the requirements on system Y capacitance are also correspondingly increased. In the charging system, Y capacitance will affect the insulation detection effect.

The standard use is mainly reflected in the standard use of charging facilities and charging resources. Non-standard charging operation will lead to charging failure, so it is necessary to strengthen standardized operation guidelines, cultivate good operating habits of drivers, and reduce equipment damage. If charging resources cannot be used in a standard way, the situation of "difficult to park" and "difficult to charge" will be deteriorated. How to solve the problem of oil vehicles occupying space in some public parking lots in terms of station operation, install floor lock equipment or put it into the administrator or other means? It is an important problem that troubles the operator.

### 3. Charging Facility Quality Improvement

With the rapid development of China's EV charging industry and the accelerated construction of charging infrastructure, problems such as charging interoperability and security in the long-term operation of charging infrastructure are gradually exposed.
3.1. Improve the Quality Requirements of Charging Facilities, and Establish Vehicle Gauge Level Test Specifications
For problems encountered in the process of investigation, such as poor reliability of modules and poor durability of interfaces, the requirements of key components in charging facilities can be improved and the quality of charging facilities can be improved by establishing standards of vehicle classification. The trust mechanism of vehicle-charging certification shall be established. The work shall be carried out by the industry association, with the participation of industry enterprises. The vehicle-charging enterprises shall jointly sort out the test outline (stricter than the national standard), and issue approval marks to the products that have completed the test. In addition to improve the product quality request, the right guide for users to proper use charging infrastructure will help improve the service life of the charging infrastructure. The charging interface should be equipped with an emergency unlocking device, and clear instructions or unlocking prompts should be set at the station to avoid the use of brute force when the electronic lock cannot be normally unlocked.

3.2. Establish Remote Monitoring and Diagnosis Platform for Charging Facilities
At present, the on-site detection management mode of charging infrastructure is still dominated by manual recording of detection data. It lacks the means of remote detection and fault analysis, and the real-time detection data is poor. As a result, the effective analysis and management of the detection data of charging infrastructure cannot be completed, which seriously affects the efficiency and reliability of the operation and maintenance management of charging infrastructure. Therefore, it is urgent to carry out research on remote detection and diagnosis technology of key performance indicators of charging infrastructure, especially research on key technologies of remote detection of charging interoperability and security of ev charging infrastructure. The development of electric vehicles and charging infrastructure compatibility test analysis system, charging pile master plate - billing control unit communication link health condition monitoring system, charging infrastructure security detection analysis system and comprehensive remote cloud platform based remote testing and diagnosis system, charging infrastructure for electric vehicle charging infrastructure standardization of testing will be quite urgent.

3.3. State Monitoring of Charging Infrastructure
Charging operators should maintain supervision over the state of the charging infrastructure, achieve real-time online monitoring and timely fault judgment, especially the temperature monitoring and fault judgment of the charging interface. In addition, charging operators should clearly guide the customers to conduct charging series operations, and timely inform the customers of charging information and fault information, which can be displayed on screen or charging APP.

3.4. Establish a Standardized Inspection and Maintenance System
Charging operators should establish a standardized inspection and maintenance system. Carry out regular inspection of the charging infrastructure, including but not limited to:
① charging interface, interface cleaning (whether there is magazine dust), charging interface terminal (whether there is wear or loose), anti-contact cap (whether there is falling off), shell (whether there is cracking affect the protection level), mechanical lock (lock structure is effective), etc.;
② charging cable, whether wear, whether normal connection, etc.;
③ Display screen (charging terminal with display screen), screen clarity, touch screen sensitivity, screen integrity;
④ charging two-dimensional code, artificial damage or aging damage, such as unable to scan code; If there is a problem, it should be repaired in time. If it cannot be repaired in time, there should be an obvious sign indicating the failure status (there is synchronous update in the charging APP).
4. Conclusion and Suggestions
The development of electric vehicles has led to the development of charging facilities. During the rapid development, some problems have been exposed gradually. Through research and analysis, some of these problems can be avoided by improving product quality requirements. The final recommendations of this study are as follows:
(1) In terms of product design, improving the protection level of the power module can significantly reduce the failure rate of the product. The charging module can be isolated from the external air by using the whole pile heat exchange technology, and it also can be isolated from the air duct to reduce the damage caused by dust, oil and salt spray during air circulation.
(2) Strengthen on-line condition monitoring, optimize control logic, reduce the impact of surge current, over-temperature, power grid fluctuation, bad weather on equipment. High attention should be paid to the maintenance of charging infrastructure, especially to ensure the replacement cycle of wearing parts. For such wearing parts as charging interface and electronic lock, fixed replacement cycle should be set, such as fixed number of plug and unplug, fixed service period, etc.
(3) Standardize product installation and operation procedures. Clear instructions for use and troubleshooting are set at the station to guide users to properly care for charging equipment and reduce artificial damage.
(4) We should strengthen industrial cooperation and establish a vehicle-pile certification mutual trust mechanism. The way of carrying out the work is to promote the quality improvement of charging facilities together with the participation of industry associations and enterprises. In the future, it is suggested that based on this conclusion, from the perspective of improving the quality of charging infrastructure, the research and development verification system of various automobile enterprises should be used for reference, and a test specification for the vehicle grading requirements of charging infrastructure should be formulated to further strengthen the quality requirements of charging infrastructure.

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