

Research on Maintenance Capability Standards for Drive Motor Systems of New Energy Vehicles

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Abstract: Developing industry recognized industry standards within the qualification framework is the benchmark for learning outcomes transformation. Based on the study of general competency standards, this article takes the maintenance competency requirements of new energy vehicle drive motor systems as a case study, and conducts a detailed analysis of the requirements for this module in vocational education undergraduate education for secondary and higher vocational schools. Finally, the vocational skill level standard for "electric vehicle high-voltage system evaluation and maintenance" is revised and preliminarily verified.

Keywords: Capability Standards; New Energy Vehicles; Drive Motor Systems.

1. Introduction

According to the perspective of the International Economic Cooperation Organization, the lifelong education qualification framework is defined as "building a continuous and recognized qualification ladder based on the requirements of knowledge, skills, and abilities", which includes not only academic education within institutions, but also explicit and implicit abilities held by non-institutions. Explicit abilities include knowledge and skills, while implicit abilities include attitudes, cognition, and emotions. The qualification framework, as a lifelong learning "overpass" for national, regional, and even international recognition, is an important way to promote communication and mutual recognition of learning outcomes at all levels and types of education. Under the qualification framework, studying the development of vocational ability level standards can achieve the recognition, credit accumulation, and conversion of various learning outcomes. This article takes the new energy vehicle field, which is most representative of the "four new" economic characteristics, as a case study. Based on the previous vocational education qualification framework, it explores the establishment of ability standards for the maintenance of the

core components of new energy vehicles, such as the drive motor controller. A pilot study is conducted on the recognition, credit accumulation, and conversion of various learning outcomes within the institution.

2. General Competency Standards

The level of vocational education qualification framework follows the complexity level of technical activities, while taking into account objective factors such as the cognitive acceptance level of students, industry economic development needs, and cultural traditions. Generally, the national qualification framework is based on the level of academic education, which is also suitable for the vocational education qualification framework. The main reasons are as follows: firstly, academic education has strong stability, and with the development of technology, it will affect academic education, but it will not cause it to disappear, but vocational certificates may disappear with the disappearance of professions; Secondly, the recognition of academic education is higher than that of vocational qualification certificates, which is also one of the reasons for the low recognition of vocational education;

Table 1. Correspondence between Educational Level and Ability Standards

Educational level	Scope of Work	criterion of competence
Secondary vocational school	Standardized technical work	Using standardized techniques within a known scope to engage in various specific tasks in familiar and occasionally controllable unfamiliar fields of work
higher vocational education	Work using logical analysis methods	Using logical analysis methods to apply proven technical skills in a controllable and unfamiliar work field
Vocational Education Undergraduate	Work utilizing comprehensive analysis and decision-making	Solving problems in controllable or uncontrollable unfamiliar work areas using methods that have not been fully proven effective

Finally, the systematic nature of academic education is strong, and legal classification has been formed in educational policies. The vocational skills certificate is still far from being achieved, which is also one of the problems to be solved in the construction of the vocational education qualification framework. Using a comparative method to study the

qualification framework for vocational education both domestically and internationally, taking into account China's national conditions, the educational level includes secondary vocational education, vocational education, and vocational education undergraduate. The correspondence between educational level and competency standards is shown in Table

1.

3. Industry Status of New Energy Vehicle Drive Motor System Maintenance

The drive motor system, as one of the core components of new energy vehicles, is the key to achieving the conversion of electrical and mechanical energy in the entire vehicle. The process of electrification of automobiles is constantly accelerating, and the electrification of driving systems is crucial. New energy vehicles replace fuel engines with electric motor systems, driven by electric motors without the need for automatic transmissions. Compared to automatic transmissions, the motor has a simple structure, mature technology, and reliable operation. With the rapid development of the new energy vehicle industry, the market size of the drive motor system has also achieved rapid growth. From 2017 to 2022, the installed capacity of drive motor systems for new energy vehicles in China increased from

850000 units to 4.19 million units, with a CAGR of 37.58%. In the future, with the further increase in the penetration rate of new energy vehicles in China and the gradual promotion of dual drive motor models, the installed capacity of drive motor systems is expected to continue to grow.

There are two development directions for integrated drive motor systems. One is power integration, which integrates the drive motor, motor controller, reducer, and even more components into a multi in one electric drive system, as shown in Figure 1 (a); The second is control system integration. The integrated controller for passenger vehicles includes a drive motor controller, DC/DC, high-voltage distribution box, on-board charger, and insulation detector, as shown in Figure 1 (b). Commercial vehicles also include steering oil pump DC/AC and air pump DC/AC. Integration can achieve miniaturization and lightweighting of electric drive systems, reduce weight and volume, and lower costs, freeing up space to a certain extent and facilitating vehicle layout.



(a)



(b)

Figure 1. Integrated System

From the research of the new energy vehicle industry and the drive motor system industry, it can be seen that the market size of this industry is very large, and there is a shortage of operators in maintenance, installation, testing, and repair. There is no problem in cultivating skilled talents for employment and export.

4. Standard Requirements for Maintenance Capability of Drive Motor Systems for Vocational New Energy Vehicles

The ability standard required for graduating from a

vocational school is to apply standardized techniques within a known range to engage in various specific tasks in a familiar and occasionally controllable unfamiliar field of work. Here, standards refer to industry standards, local standards, national standards, international standards, manufacturer standards, and manufacturer manuals. As training is focused on common skills, manufacturer standards or manuals are usually used as the standard for tools or specialized operating objects. In addition, national standards are usually selected. If there are no national, local, or industry standards in China, international standards will be used.

Table 2. Standards used for insulation detection tasks of drive motors

Operation items	Standards or specifications	Type
1. Inspection of high-voltage maintenance operators	DB12/T1074	Tianjin Local Standards
2. Inspection of high-voltage maintenance site	High voltage management standards for electric vehicle maintenance sites	
3. Calibration of insulation testing instruments	Product manual	Component Product Manual
4. Drive motor insulation detection	GB/T 18488.1-2015 Drive Motor Systems for Electric Vehicles Part 1: Technical Conditions	National recommended standards
	GB/T 18488.2-2015 Drive Motor Systems for Electric Vehicles Part 2: Test Methods	

Taking the insulation testing task of new energy vehicle drive motors as a case study, this task is aimed at conducting insulation testing tasks for drive motors after leaving the factory, repair, or maintenance. All operation items are carried out under standardized operating procedures, and the operating environment is familiar with the working conditions. The standards and specifications used in the operation for the insulation testing task of drive motors are shown in Table 2.

There is no national standard for the maintenance personnel and site specifications of new energy vehicles, which poses certain risks in the industry. In 2020, the author organized a research group to apply for and obtain the local standard DB12/T1074-2021 (High Voltage Management Specification for Electric Vehicle Maintenance Sites) in Tianjin. In 2021, it was officially approved and applied to the electric vehicle maintenance industry in Tianjin, standardizing the standardization of the new energy vehicle maintenance industry.

5. Standard Requirements for Control and Maintenance Capabilities of New Energy Vehicle Drive Motors in Vocational Colleges

The ability standard required for vocational college

graduation is to use logical analysis methods to apply fully proven technical skills in a controllable and unfamiliar work field. The corresponding positions in the maintenance industry of new energy vehicle drive motor systems include simple fault diagnosis, functional testing, and simple process improvement. Here, we take simple fault diagnosis of new energy vehicle drive motor systems as a case study.

Taking BAIC EU260 as a case study, the fault codes and definitions for the drive motor system in the maintenance manual are shown in Table 3. The fault information includes fault codes, frozen data frames, and data streams. The faults can be divided into two categories: simple faults, which have obvious directionality and can be confirmed through fault data analysis; The second type is comprehensive faults, which have complex causes and are usually caused by multiple fault causes or points that affect each other. Among them, simple faults are basically consistent with the ability standards required for vocational college graduates. Here, the motor controller temperature sensor fault is taken as an example. This type of fault requires understanding of the structure and temperature sensor type of the drive motor controller. The structure of the drive motor controller is shown in Figure 2 (a). The motor controller temperature sensor includes two categories: the built-in temperature sensor of the power electronic device and the external temperature sensor. Here, the external temperature sensor is taken as an example, as shown in Figure 2 (b).

Table 3. Fault codes and definitions of BAIC EU260 drive motor system

Fault Code	Fault Definition
P0519	Motor Overspeed Protection Fault
P0520	Motor Temperature Sensor Short Circuit Fault
P0772	Motor System Life Signal Fault
P1280	Motor Overheat Fault
P1793	Motor Power Generation Mode Failure Fault
P0031	Motor Controller IGBT Fault
P0032	Motor Controller 12V Momentary Open Circuit Fault
P0035	Pre-charge Fault
P0512	Motor Controller Temperature Sensor Fault
P0514	Motor Controller Temperature Sensor Open Circuit Fault
P0515	Motor Controller CAN Fault
P0516	Motor Controller Overcurrent Fault
P0517	Motor Controller Overvoltage Fault
P0518	Motor Controller Undervoltage Fault
P0521	Motor Controller Phase Current Overcurrent Fault
P0771	Motor Controller Feedback Mode Fault

The fault of the temperature sensor in the motor controller is caused by the sensor itself. The drive motor controller can be disassembled as a whole according to the correct high-voltage operation specifications or the temperature sensor of the motor controller can be disassembled. The temperature sensor status can be detected to confirm the fault point, and the drive motor controller or motor controller temperature sensor can be installed. Finally, a road test can be conducted.

6. Standard Requirements for Control and Maintenance Capabilities of New Energy Vehicle Drive Motors for Undergraduate Vocational Education

The ability standard required for vocational education undergraduate graduation is to use methods that have not yet been fully proven effective to solve controllable or uncontrollable problems in unfamiliar work fields. The comprehensive faults of the drive motor system of new energy

vehicles are consistent with such problems. When solving comprehensive faults, fault tree analysis is usually required.

The fault tree of the drive motor controller is shown in Figure 3.

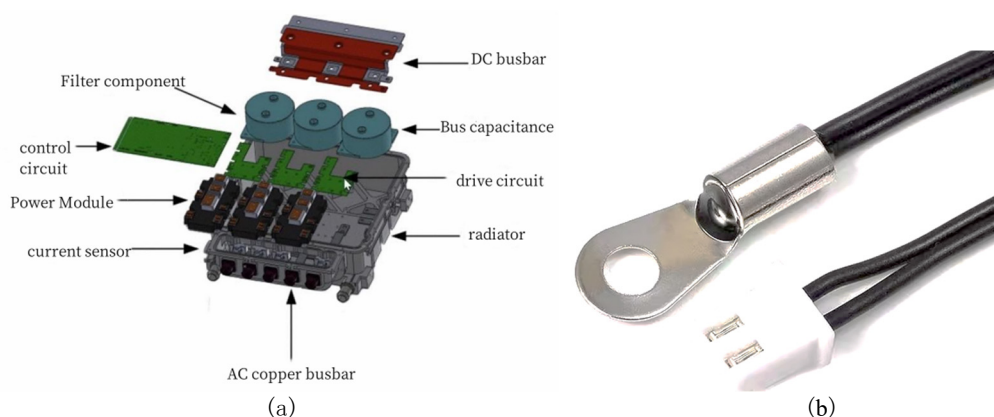


Figure 2. Structure of Drive Motor Controller and Temperature Sensor

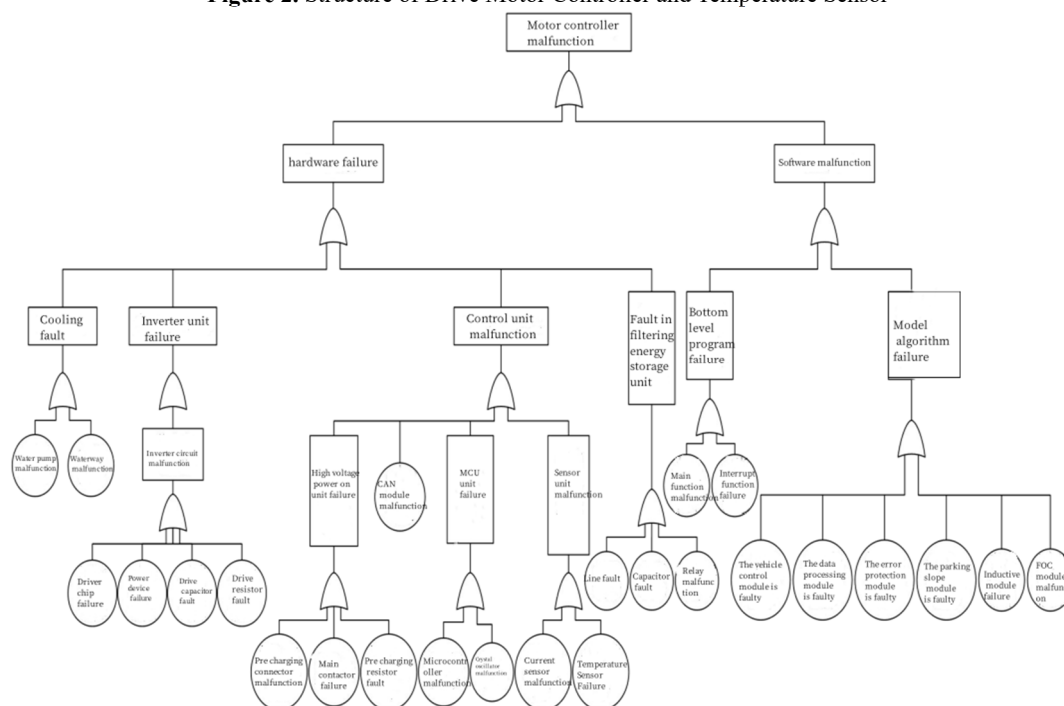


Figure 3. Fault Tree of Drive Motor Controller

Taking the overheating fault of the drive motor as an example, the causes may include long-term overload, drive motor failure, drive motor controller failure, cooling system failure, and fault information reporting failure. The causes of the faults may have a chain effect and mutual influence, requiring comprehensive analysis and investigation one by one.

7. Conclusion

Based on the vocational education qualification framework system, the maintenance capability requirements for the drive motor system of new energy vehicles have been developed. The fourth batch of 1+X vocational skill level standards, "Evaluation and Maintenance of Electric Vehicle High Voltage Systems," have been revised and a modular course has been formed. The unified and standardized modular course provides conditions for the recognition, credit accumulation, and conversion of learning outcomes.

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