Research on the Construction of High-mobility Multifunctional Emergency Rescue Equipment Standard System

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Abstract—In order to regulate and guide the high-quality development of the emergency rescue equipment industry, it is necessary to establish a perfect emergency rescue equipment standard system. The development status of emergency rescue equipment and standards was analyzed. China’s demand for emergency rescue equipment and standards was studied from different aspects. The results show that China is in urgent need of high-mobility multifunctional emergency rescue equipment and relevant standards. Based on the analysis, this paper proposes the basic principles, construction methods and dimensions model of the construction of China's emergency rescue equipment standard system, and builds a standard system framework of high-mobility multifunctional emergency rescue equipment, which is conducive to improving the standardization construction in the field of emergency rescue and continuously improving China's emergency rescue capabilities.

1. INTRODUCTION

China is a country with frequent natural disasters and unexpected disasters occurred, such as fire, flood, snow, and earthquake. With the acceleration of the urbanization process, all kinds of sudden disasters have increased sharply, and they have shown characteristics of diversity and complexity, which have caused serious losses of people's lives and property. In 2017, China's various natural disasters caused 140 million person-times, damaged 1.732 million houses, and caused direct economic losses of 301.87 billion yuan. However, the technical level of disaster emergency rescue equipment in China is seriously lagging behind, with single functions, poor mobility, and low degree of specialization, which leads to untimely and inefficient rescue and exacerbates the degree of damage.

Although the emergency industry is developing rapidly and the number and types of emergency rescue equipment are constantly increasing in the past few years, China's emergency rescue equipment standard system is incomplete, emergency rescue equipment standards are seriously lacking and there is no unified planning, which cannot effectively regulate and guide the development of the emergency rescue equipment industry.

2. STATUS ANALYSIS OF EMERGENCY RESCUE EQUIPMENT AND STANDARDS IN CHINA

2.1. Analysis of the status of emergency rescue equipment
At present, emergency rescue equipment plays a pivotal role in emergency rescue work. However, due to the single mechanical function and poor mobility, there are certain problems and deficiencies in the actual rescue process. At present, these shortcomings of emergency rescue equipment have become a bottleneck restricting the efficiency of China's major disaster rescue, especially reflected in the following aspects.

First, there are large differences between urban and rural areas in China, and the development of infrastructure is uneven. Large-scale accidents are often accompanied by road damage, traffic and communication interruptions. Due to the large size and weight of existing equipment, poor off-road performance and low self-driving speed, often need to rely on other large vehicles for transportation. As a result, rescuers, equipment, and daily necessities cannot reach the scene quickly, thereby delaying rescue time;

Second, the existing equipment often has a single function and requires supporting operations. It has poor applicability to the narrow space of the rescue site, and various types of equipment of various manufacturers also have problems such as poor versatility and poor replacement efficiency, which greatly affects the efficiency of on-site rescue;

Third, the existing emergency rescue equipment is often a general-purpose equipment that is temporarily deployed and used without special design adaptation, commissioning and testing. The performance is unstable and the failure rate is high under difficult conditions, making it difficult to perform rescue tasks.

2.2. Analysis of the status of emergency rescue equipment standards

The so-called laws and regulations can be followed to improve work efficiency. At present, the number of domestic emergency rescue equipment standards does not match the development speed of emergency rescue work, and it cannot effectively regulate and guide the development of emergency rescue equipment. Although China's emergency rescue equipment and its standard system are not yet complete, it already has a certain foundation. The relevant national standardization technical committees have formulated some relevant national and industry standards. Among them, a certain standard system has been formed for fire emergency and earthquake emergency rescue.

2.2.1. Status of fire emergency rescue equipment standards: After more than 20 years of development, China's fire-fighting equipment industry has developed to a certain scale. It has been able to produce various types of fire-fighting equipment. The fire-fighting standard system has become increasingly complete. The standard categories are basically complete. The emergency rescue equipment standards have no clear classification and are scattered into the sub-technical committees.

With regard to the construction of domestic fire emergency rescue equipment standards, the fire emergency rescue equipment is divided into 12 categories and 224 types of fire emergency rescue equipment based on GB/T 29178-2012 "Fire Emergency Rescue Equipment Guidebook", Construction Standard 152-2011 "Urban Fire Station Construction Standard" and "Fire Equipment and Application Manual". Through statistical analysis, 64 types of existing 224 types of fire emergency rescue equipment in the 12 major categories have relevant standards that can be checked, as shown in Table 1.

Through the above analysis, we can see that the overall lack of fire emergency rescue equipment standards in China is relatively high, especially the standards for plugging, transmission, and decontamination fire equipment are still blank, while lacking high mobility and multifunctional fire emergency Rescue equipment and corresponding standards [1].

| Item | Major equipment category | Number of equipment types | Number of equipment with standards | Standard lack rate |
|------|-------------------------|--------------------------|----------------------------------|-------------------|
| 1    | Detection               | 23                       | 4                                | 83%               |
| 2    | Alert                   | 8                        | 1                                | 88%               |
| 3    | Life-saving             | 25                       | 7                                | 72%               |
2.2.2. Status of earthquake emergency rescue equipment standards: At present, the earthquake industry does not have a standard system for earthquake emergency rescue equipment. According to the earthquake industry standard DB/T57-204 "Classification, Codes and Labels for Earthquake Rescue Equipment", it can be known that earthquake emergency rescue equipment is divided into detection equipment, search equipment, rescue equipment, medical equipment, communication equipment, assessment and information equipment, logistics equipment, rescue vehicles in eight categories.

| TABLE 2. STATISTICS OF PROFESSIONAL STANDARDS FOR EARTHQUAKE EMERGENCY RESCUE |
|---------------------------------|---------|---------|----------------|
| Standard category               | Due number | Existing number | Existing number / Due number (%) |
| National standard               | 62       | 12       | 20             |
| Industry Standard               | 45       | 3        | 6              |
| Total                           | 107      | 15       | 14             |
| Basic standard                  | 11       | 0        | 0              |
| Technical standard              | 23       | 8        | 35             |
| Management standards            | 27       | 1        | 4              |
| Equipment Facility              | 19       | 4        | 21             |
| Product Standard                |          |          |                |
| Comprehensive standard          | 27       | 2        | 7              |
| Total                           | 107      | 15       | 14             |

According to statistics, the currently issued standards only have four earthquake emergency rescue equipment standards, including DB/T 42-2012 "Seismic rescue equipment inspection procedures-hydraulic power tools", DB/T 43-2012 "Seismic rescue equipment inspection procedures-lifting air cushion system", DB/T 44-2012 "Earthquake rescue equipment testing procedures-internal combustion engine power tools" and DB/T 57-2014 "Earthquake rescue equipment classification, code and label". As shown in Table 2, so China's existing Earthquake emergency rescue equipment standards cannot meet the needs of earthquake emergency rescue work. It is necessary to establish standard specifications in terms of emergency rescue equipment terminology, commonly used signs, and rescue capability indicators. High-mobility, multifunctional emergency rescue equipment plays a vital role in
rescue work, and the standards for earthquake emergency rescue equipment should be continuously developed and improved in the practice of earthquake emergency rescue [2].

3. CHINA'S DEMAND FOR EMERGENCY RESCUE EQUIPMENT AND STANDARDS

At present, relevant machinery manufacturers at home and abroad have conducted some research on high-mobility multifunctional emergency rescue equipment, but the number of equipment is small and the quality is uneven, which cannot effectively meet the market demand. The typical equipment with relatively mature technology includes the following.

High-mobility backhoe loader. Backhoe loader has both digging and loading functions. It adopts 4-wheel drive and the maximum travel speed can reach 8090 km / h, as shown in Figure 1.

![High-mobility backhoe loader](image1)

Figure 1. High-mobility backhoe loader

Multifunctional obstacle-breaking vehicle, which is a combination of bulldozing, lifting, shearing, digging, and demolition. As shown in Figure 2, it can quickly clear landslides, collapses, and rocks when the road is damaged. Quickly open roads to grab the road, and the speed can reach 130 km / h.

![Multifunctional rescue vehicle](image2)

Figure 2. Multifunctional rescue vehicle

Multifunctional emergency rescue robot, with dual functions of grabbing and cutting, and can perform compound switching of wheels and tracks; it can realize remote control operation within 500 meters, as shown in Figure 3. The device played an important role in the Ya An earthquake rescue, completing many actions and rescue work that were not possible with conventional rescue equipment.

![Two-arm rescue robot](image3)

Figure 3. Two-arm rescue robot

In addition, it also includes highly mobile multifunctional emergency rescue equipment such as all terrain engineering rescue vehicles, all terrain excavators and amphibious excavators.
High-mobility, multi-functional, and high-efficiency emergency rescue equipment is a requirement for the current development of emergency rescue work, and it is a development requirement for handling complex rescue conditions and improving rescue efficiency. With the rapid development of the emergency industry, the number and types of high-mobility and multi-functional emergency rescue equipment have continued to increase, which has played an important role in emergency rescue activities and has also raised higher requirements for standardization work.

First of all, the requirements of the emergency rescue industry for timeliness, quality, and functions are fundamentally different from those of other industries. They have stringent requirements for the reliability, adaptability, and mobility of emergency rescue products. At present, there are fewer standards for high-mobility and multi-functional emergency rescue products, which is not conducive to market supervision and product specifications;

Secondly, due to the high-mobility and multi-functional technology development trend of emergency rescue equipment, higher requirements are imposed on the generalization, modularization, and standardization of products of various manufacturers, and special standards are required to ensure the application of technology;

Third, the current standards for high-mobility and multifunctional emergency rescue equipment lack unified management, lack of pertinent standards formulation, and lack of coordination among standards. It is difficult to implement the standards, and it is impossible to effectively monitor and regulate the quality of high-mobility and multifunctional emergency rescue equipment, which seriously affects the development of the industry and technological progress.

Therefore, at present, it is necessary to establish a standard system that meets the needs of the development of the industry, to uniformly plan and manage relevant standards for high-mobility multifunctional emergency rescue equipment, to develop a complete, coordinated and unified standard to promote product technology innovation and promote the standardization of R & D, manufacturing, verification and application of high-mobility multifunctional emergency rescue equipment [3].

4. CONSTRUCTION OF EMERGENCY RESCUE EQUIPMENT STANDARD SYSTEM

4.1. Basic principles
According to the basic requirements for the construction of a standard system and the characteristics of the emergency rescue industry standard system construction, the construction of a high-mobility multifunctional emergency rescue equipment standard system should comply with the following basic principles, with clear goals, complete structures, clear levels, reasonable application, suitable for national conditions, International integration, dynamic improvement and openness.

4.2. Construction method of standard system
The high-mobility and multi-functional emergency rescue equipment standard system is constructed in accordance with the "four-step method" principle.

The first step is to clarify the research content and product scope of this standard system.

The second step is to study the current status of emergency rescue vehicle and vehicle equipment standard systems at home and abroad, extract common abstract features, identify existing and missing standards related to domestic high-mobility multifunctional emergency rescue equipment, and clarify the gap between standards crossover relationship.

The third step is to build a standard system framework on the three dimensions of high mobility, multi-functionality and efficiency in accordance with China's specific national conditions and market needs, analyse the logical relationship between the various levels of the standard system architecture, and determine the scheme of standard system.

The fourth step is to decompose the standard system structure to form a highly mobile multifunctional emergency rescue equipment standard system, and guide the formulation and revision of the high mobile multifunctional emergency rescue equipment standard [4].
4.3. Dimensional Model of Standard System

According to the research object and research content analysis, the basic dimension model of the high-mobility and multifunctional emergency rescue equipment standard system is determined, including the level dimension, nature dimension, emergency rescue process dimension, and event type dimension, as shown in Figure 4.

4.3.1. Level dimension: Mainly refers to the standard level. For the established high-mobility multifunctional emergency rescue vehicle and vehicle equipment standard system, the standards covered by the standard include national standards, industry standards, local standards, and enterprise standards. Among them, the national standard refers to the relevant national standards for high-mobility multifunctional emergency rescue vehicles and vehicle-mounted equipment, and the industry standards refer to the high-mobility multifunctional emergency rescue vehicles and vehicle-mounted equipment related standards that occur and handle emergency rescue events in the industry. Local standards refer to standards for emergency rescue equipment that require special requirements in an administrative area, and enterprise standards mainly refer to standards required by emergency rescue equipment manufacturers.

4.3.2. Nature dimension: It mainly refers to the nature of standards, including four parts: basic standards, general technical standards, key equipment standards, and test verification standards. Among them, the basic standards mainly refer to basic standards such as the definition of terms, graphic symbols, signs, product classifications, and packaging related to emergency rescue equipment; the general technical standards refer to the general technical methods and materials used by emergency rescue equipment involved in this standard system. Standards such as modular design methods; key equipment standards are the core part of this system, mainly including product standards related to high-mobility multifunctional emergency rescue equipment; test verification standards are standards such as test methods and inspection rules for equipment involved in this standard system.

4.3.3. Emergency rescue process dimension: It is mainly the emergency rescue process involved in this standard system. According to China's emergency response law, it includes four main stages: prevention and emergency preparedness, detection and early warning, emergency disposal and rescue, and recovery and reconstruction. This standard system mainly studies high-mobility and multifunctional emergency rescue equipment used in emergency rescue processes.

4.3.4. Event type dimension: Mainly refers to the type of rescue events corresponding to the emergency rescue equipment involved in this standard system, including natural disasters, sudden accidents, etc., excluding aviation rescue. Among them, natural disasters mainly include fires, floods, landslides, earthquakes, wind disasters and their secondary disasters; sudden accidents mainly include traffic accidents, hazardous chemical accidents and social assistance events [5].

Figure 4. Content dimensions of the standard system
4.4. Standard system framework
The establishment of a high-mobility multifunctional emergency rescue vehicle and vehicle equipment standard system adopts the hierarchical structure of the industry standard system table in GB/T 13016-2018 "Standard System Table Construction Principles and Requirements". The high-mobility and multifunctional emergency rescue vehicle and on-board equipment standard system framework includes four parts: "basic standard", "general technical standard", "key equipment standard" and "test and validation standard", as shown in Figure 5.

5. SUMMARY AND OUTLOOK
The standard system is an important support for clarifying the relationship between the standardization needs of application objects, and is a top-level design method in standardization work. It plays a very important role in the development of standardization in China [6].

The establishment of a high-mobility, multi-functional emergency rescue equipment standard system is a process of continuous improvement, which needs to be based on the standard system framework and continuously improved and refined in accordance with China's economic and social development. At the same time, in view of the current weak links in emergency rescue work in China, we should focus on the coordination and consistency of emergency rescue equipment standards, focus on the common foundation and common technical standards of emergency rescue, and establish a systematic emergency rescue standard system to improve scientific and overall emergency capabilities of emergency rescue work.

At the same time, according to the development status of related standards for high-mobility and multi-function emergency rescue vehicles and on-board equipment in China and the industry's demand for related standards, it is proposed to develop a number of important standards that can promote the promotion of industrial technology and enhance industrial competitiveness, standardize the research & development, manufacturing, testing and application of high-mobility multi-function emergency rescue equipment.
vehicles and on-board equipment, promote product technological innovation, and continuously improve China's emergency rescue capability.

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