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校企合作双元开发活页式新形态一体化教材
高等职业教育铁道运输类“十四五”技能型人才培养实用教材

EMU Structure and Maintenance

动车组结构与维修（活页式）

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·成　都·

内容简介

本书为广州铁路职业技术学院与海外联合办学所使用的教材，适合双语教学。本书主要内容包括动车组机械设备的组成、结构、工作原理及维护与检修，图文并茂、通俗易懂。本书内容侧重基础，同时配以数字化的教学资源，以提高学生的整体认识，使学生初步了解动车组的一些基本概念和动车组一级修的内容。本书主要适用于动车组检修技术专业留学生作专业教材。

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前　言

随着中国高铁走出去的战略，中国铁路在东南亚各国取得了丰硕成果。在高铁装备走出去的同时，中国铁路的技术标准、管理标准等都将全面走出去。轨道交通维护与检修专业人才需求量越来越大，在轨道交通教育同步走出去的同时，轨道交通人才本地化也显得越来越重要。广州铁路职业技术学院主动对接国家“一带一路”倡议，与马来西亚拉曼大学学院开展合作办学，共同培养能从事动车组列车检修的一线岗位技术技能人才。

本教材根据动车组机械结构检修课程标准，并参考《铁路技术管理规程》《铁路动车组运用维修规则》《铁路动车组设备设计规范》等国铁集团规章和文件编写而成。

“动车组机械结构检修”是动车组检修技术专业的一门专业核心课，也是广州铁路职业技术学院招收马来西亚拉曼大学学院留学生必修课程之一，目的是让学生认识动车组的整体机械结构组成，使学生掌握动车组的车体、转向架、车体连接装置、基础制动装置等检修技能，具备动车组机械师的检修作业能力。

本教材实行以“项目导向、任务驱动、理实一体化”的教学模式，内容以动车组的构造和动车组的检修为主线，按照动车组的认识、动车组检修认识、动车组车体结构与检修、动车组转向架结构与检修、动车组车端连接装置结构与检修五个项目分层介绍，每一个项目都配有带有中英双语字幕的教学微课数字化资源，检修内容配有在动车组车间拍摄的实操演示视频，以最真实的一线车间工作任务展示动车组结构检修的过程，使学生直观了解动车组检修的全过程，培养学生遵章守纪、规范操作的职业意识。

本教材由广州铁路职业技术学院南松、滕世平主编，中国铁路广州局集团有限公司广州动车组段牛刚副主编，中车唐山机车车辆有限公司李会杰，广州铁路职业技术学院刘志运、马冬、颜秀珍，中国铁路武汉铁路局襄阳机务段将帅参编。

本教材在编写过程中参考了许多相关资料，谨向这些资料的作者致以最诚挚的谢意。

由于编者水平有限，书中难免存在不足之处，敬请广大读者提出宝贵意见和建议，以便在修订时改进。

编　者

2022 年 9 月广州

PREFACE

With China high speed railway export strategy, China railway has achieved fruitful results in Southeast Asian countries. While the high speed railway equipment is being exported, the technical standards and management standards of China railways will be fully promoted overseas. The demand for railway maintenance technicians is increasing. While railway education is overseas, the localization of railway personnel training is becoming more and more important. Guangzhou Railway Polytechnic takes the initiative to connect with the national “The Belt and Road initiative” and cooperates with the UTAR Malaysia in running schools to jointly cultivate technical and skilled personnel who can be engaged in the maintenance of EMUs.

This book is compiled according to the course standards for the EMUs mechanical structure, and with reference to the “Technical Management Rules of Railway”“Rules for Operation and Maintenance of EMUs” “Railway EMUs Equipment Design Specification” and other regulations and documents of China State Railway Group Co., Ltd.

“EMUs mechanical structure maintenance” is a professional core course for EMUs maintenance technology major and it is also one of the compulsory courses for Guangzhou Railway Polytechnic to recruit international students from UTAR Malaysia. The aim is to let the students grasp the overall mechanical structure of the EMUs, so that the students can master the maintenance skills of the EMUs body, bogie, end connection device, foundation braking device, etc., and have the maintenance operation ability of the EMUs mechanic.

This book implements the teaching mode of “project-oriented, task-driven, theory and practice integration”. The content is based on the structure of the EMUs and the maintenance of the EMUs. According to recognizing EMUs, EMUs maintenance, EMUs body structure and maintenance, EMUs bogie structure and maintenance, EMUs end connection device structure and maintenance, the five projects are introduced. Each project is equipped with digital resources for teaching microlecture with Chinese and English subtitles. The maintenance content is equipped with a practical demonstration video shot in the EMUs workshop, showing the process of EMUs structural maintenance with the most real front-line workshop tasks, so that students can intuitively recognize the whole process of EMUs maintenance, and train students to abide by the rules and regulations and operate in a standardized way. professional awareness.

This book chief editors are Nan Song and Teng Shiping of Guangzhou Railway Polytechnic, associate editor is Niu Gang of Guangzhou EMU Depot of China Railway Guangzhou Group Co.， Ltd.， Li Huijie of CRRC Tangshan Co., Ltd，Liu Zhiyun, Ma Dong and Yan Xiuzhen of Guangzhou Railway Polytechnic, and Xiangyang Locomotive Depot of Wuhan Group Co.，Ltd.，participated in the edit.

Many relevant materials have been referenced in the preparation of this book, and I would like to express my sincerest gratitude to the authors of these materials.

Due to the limitation of knowledge, there are inevitably shortcomings in the book. Readers are expected to provide valuable comments and suggestions for improvement during revision.

Authors
2022.9 Guangzhou

CONTENTS

Chapter 1

Recognizing EMUs

Learning objectives

- Know the high-speed trains of various countries;
- Recognize the different types of EMUs;
- Understand Chinese high speed train numbering rules;
- Become familiar with the components of EMUs.

1.1 High-Speed Trains Around the World

1.1.1 High-Speed Trains in Japan

The Shinkansen is a high-speed railway system in Japan and the first high-speed railway system in the world to be put into commercial operation. It uses a standard 1435 mm gauge and operates purely passenger services. Initially, it was built to connect distant Japanese regions with Tokyo, the capital, to aid economic growth and development. Beyond long-distance travel, some sections around the largest metropolitan areas are used as a commuter rail network. The first line was the Tokaido Shinkansen between Tokyo and Osaka. It was opened to traffic on October 1st, 1964 before the start of the Tokyo Olympics. After years of expansion, there are currently 9 lines, including 2 shorter lines. The "mini Shinkansen" connect the most important cities in Japan. It was originally developed and operated by the Japanese state-owned railways, and after the division and privatization of the National Railways, it was continued by the JR Group. Currently, there are 5 JR companies providing services, including JR Hokkaido, JR East Japan, JR Tokai, JR West Japan and JR Kyushu.

The Shinkansen is designed to be take account of load capacity and high speed.

Therefore, its construction and operation technology are different from traditional railways. For example, Shinkansen trains use decentralized power, three-dimensional intersections and were the first trains to use an automatic train control system. The departure interval time of Shinkansen trains can be as low as 3 min. Bar the mini Shinkansen, the trains can reach a maximum speed of 240 to 320 km/h depending on the line. However during the speed test, it set a record of 443 km/h (set by the “300X” experimental train in 1996), and a world record 603 km/h for SC Maglev trains in April 2015. As an important symbol of Japan’s top railway technology across the globe, Shinkansen technology is exported overseas.

Japan’s Shinkansen network had the highest number of annual passengers (353 million in 2007) of any high-speed rail network until 2011, when the Chinese high-speed railway network surpassed it at 370 million passengers annually, reaching over 2.3 billion annual passengers by 2019.

There are 15 types of Shinkansen train in Japan, among them are the 0 series, 500 series, 700 series, E2-1000 models.

1.1.1.1 0 Series Shinkansen

The 0 series trains (Fig.1.5) were the first generation Shinkansen train sets built to run on Japan’s Tokaido Shinkansen high-speed line which opened in 1964. Their maximum operating speed was 220 km/h. More than 3 200 cars were built. The design of the 0 series trains was very innovative and speedy at the time. The front of the train looked similar to that of a passenger plane and the trains were painted in a simple yet striking blue and white. The last remaining train sets were withdrawn in 2008.

Fig.1.5 0 Series Shinkansen

1.1.1.2 500 Series Shinkansen

The 500 series is a Shinkansen high-speed train type operated by the West Japan Railway Company (JR-West) on the Tokaido Shinkansen and Sanyo Shinkansen lines in Japan since 1997. They were designed to be capable of speeds of up to 320 km/h but operated at 300 km/h , until they were finally retired from the primary Nozomi service in 2010. The train sets were then refurbished and downgraded to the all-stations Kodama service between Shin-Osaka and Hakata.

The 500 series (Fig.1.6) running gear utilizes computer-controlled active suspension for a smoother, safer ride and yaw dampers are fitted between cars for improved stability. All sixteen cars in each original train set were powered, giving a maximum of 18.24 MW. Each train cost an estimated 5 billion yen and only nine were built. It used bio-mimicry to reduce energy consumption by 15%, increase speeds by 10% and reduce noise levels while increasing passenger comfort. This was done by designing the front of the train in the shape of a kingfisher's beak.

Fig.1.6 500 Series Shinkansen

1.1.1.3 700 Series Shinkansen

The 700 series is a Japanese Shinkansen high-speed train type built between 1997 and 2006, which entered service in 1999. Originally designated as "N300" during the development phase, they formed the next generation of Shinkansen vehicles jointly designed by JR Central and JR West for use on the Tokaido Shinkansen, Hakata Minami Line and the Sanyo Shinkansen. Though it has since been withdrawn from service on the Tokaido Shinkansen, the 700 series still operates on the Sanyo Shinkansen and Hakata Minami Line.

The 700 series is characterized by its flat “duck-bill” nose designed to reduce the piston effect when the trains enter tunnels. The 16-car units are painted white with blue stripes beneath the windows and are used for the Nozomi and Kodama services on the Tokaido and Sanyo Shinkansen lines, while 8-car units are used for the Sanyo Shinkansen services and have a darker livery which also acts to visually deemphasize the units’ nose area, resulting in a more streamlined impression.

As with the 500 series trains, yaw dampers are fitted between vehicles, and all cars feature semi-active suspension to ensure smooth ride characteristics at high speed. Compared with the small fleet of high-performance, high-cost 500 series trains built for JR-West, these trains were designed to give improved ride comfort and interior ambience over the earlier 300 series trains at a lower cost than the 500 series trains. The cost of a 16-car 700 series unit is approximately 4 billion yen compared with around 5 billion yen for a 16-car 500 series train.

Fig.1.7 700 Series Shinkansen

1.1.1.4 E2-1000 Series Shinkansen

The E2 series is a Japanese high-speed Shinkansen train type operated by the East

Japan Railway Company (JR East) introduced to the Tohoku Shinkansen high-speed lines in Japan in 1997. The E2 series was formed in 8 and 10-car sets. The 8-car sets were used on the Hokuriku Shinkansen, and the 10-car sets were used on Tohoku Shinkansen services. The 10-car sets could be coupled to E3 series Komachi sets using couplers hidden behind retracting nose doors. They operated at a maximum speed of 275 km/h on the Tohoku Shinkansen. A total of 502 vehicles were built between 1997 and 2010, with the first withdrawals commencing in late 2013.

The E2-1000 series (Fig.1.8) incorporated a number of design improvements compared with the earlier series, the most noticeable of which is the change from small windows for each seating bay to wide windows similar to the E4 series trains. A new single-arm pantograph design was used with an aerofoil-shaped mounting that eliminates the need for pantograph shrouds. Withdrawals of E2-1000 series sets commenced in March 2019.

Fig.1.8　E2-1000 Series Shinkansen

All Shinkansen trains adopt a decentralized drive mode to prevent hunting motion at high speed and to reduce the maintenance cost of the line. When driving the vibration is extremely small, and the overall running quality is excellent.

Comparison of Various Types of EMUs in Japan is shown in Tab.1.2.

Tab.1.2 Comparison of Various Types of EMUs in Japan

Shinkansen operating trains over the years							
Model	**V_{max}/（km/h）**	1960s	1970s	1980s	1990s	2000s	2010s
0series	220	1964 – 2008					
100series	230	1985 – 2012					
300series	270	1992 – 2012					
500series	300	1997 – now					
700series	285	1999 – now					
800series	260	2004 – now					
N700series	300	2007					
N700Sseries	300	2020 – now					
L0series	505	2027（project）					
200series	240	1982 – 2013					
400series	240	1992 – 2010					
E1series	240	1994 – 2012					
E2series	275	1997 – now					
E3series	275	1997 – now					
E4series	240	1997 – 2021					
E5series H 5series	320	2011 – now					
E6series	320	2013 – now					
E7series W 7series	260	2014 – now					
E8series	300	2024 (Project)					
Operator		Japan National Railways (1964 – 1987)			JR companies (1987 –now)		

1.1.2 High-Speed Trains in Germany

The Intercity Express (ICE) refers to the system of high-speed trains predominantly running in Germany. It also serves some destinations in Austria, Denmark, France, Belgium, Switzerland and the Netherlands mostly as part of cross border service. It is the highest service category of rail and the flagship train of the German state railway, the Deutsche Bahn. There are currently 259 train sets in operation. ICE trains are the highest category trains in the fare system of the Deutsche Bahn. Their fares are not calculated on a fixed per-kilometer table as with other trains, but instead have fixed prices for station-to-station connections, levied on the grounds that the ICE trains have a higher level of comfort. Travelling at speeds of up to 320 km/h, they are tailored for business travelers or long-distance commuters and are marketed by the Deutsche Bahn as an alternative to flights.

Apart from domestic use, the trains can also be found in countries neighboring Germany. There are ICE 1 lines to Basel and Zurich. ICE 3 trains also run to Liège and Brussels and at lower speeds to Amsterdam. On June 10th, 2007, a new line between Paris and Frankfurt/Stuttgart was opened, jointly operated by ICE and TGV trains.

The Deutsche Bahn started a series of trials in 1985 using the Inter City Experimental (ICE-V) test train. The ICE-V was used as a showcase train and for high-speed trials, setting a new world speed record of 406.9 km/h on May 1st, 1988. The train was retired in 1996 and replaced with a new trial unit, called the ICE-S.

1.1.2.1 First Generation ICE 1

The first ICE trains were the ICE 1 train sets (Fig.1.9), which came into service in 1989. The first regularly scheduled ICE trains ran from June 1991 from Hamburg – Altona to Munich at hourly intervals. The Hanover – Würzburg line and the Mannheim – Stuttgart line, which had both opened the same year, were hence integrated into the ICE network from the very beginning.

Fig.1.9 ICE 1

1.1.2.2 Second Generation ICE 2

The successor ICE 2 trains (Fig.1.10), the ICE 2, went to operation in 1997. The trains were pulled by Class 402 power heads. One key design features of ICE 2 trains was the improved load balancing which was achieved by building smaller train units which could be coupled or detached as needed.

These train sets were used on the ICE line 10 Berlin – Cologne/Bonn. However, since the driving van trailers of the trains were still awaiting approval, the Deutsche Bahn joined two portions to form a long train, similar to the ICE 1. Only in May 1998 were the ICE 2 units fully equipped with driving van trailers and could be portioned on their run from Hamm via either the stations at Dortmund, Essen, Duisburg, Düsseldorf or Hagen Wuppertal, Solingen-Ohligs.

In late 1998, the Hanover – Berlin high-speed railway was opened, which became the third high-speed line in Germany, cutting travel time on line 10 by 2.5 h.

The ICE 1 and ICE 2 trains' loading gauge exceeds that recommended by the international railway organization (UIC). Even though the trains were originally intended to be used only domestically, some units are licensed to run in Switzerland and Austria. Some ICE 1 units have been equipped with an additional smaller pantograph to be able to run on the different Swiss overhead wire layout. All ICE 1 and ICE 2 trains are single-voltage AC 15 kV, which restricts their radius of operation largely to the German-speaking countries of Europe. ICE 2 trains can run at a top speed of 280 km/h.

Fig.1.10 ICE 2

1.1.2.3 Third Generation ICE 3

To overcome the restrictions imposed on the ICE 1 and ICE 2, their successor, the ICE 3 (Fig.1.11), was built with a smaller loading gauge to permit usability throughout the entire European standard gauge network, with the sole exception being the UK's domestic railway network. Unlike their predecessors, the ICE 3 units are built not as trains with separate passenger and power cars, but as electric multiple units with underfloor motors throughout. This also reduced the load per axle and enabled the ICE 3 to comply with the pertinent UIC standard.

Two different classes were developed: the Class 403 (domestic ICE 3) and the Class 406 (ICE 3M), the M standing for multi-system. The trains were branded and marketed as the **Velaro** by their manufacturer, Siemens. The latest generation ICE 3, Class 407, is known as the New ICE 3, and is part of the Siemens **Velaro** family with the model designation **Velaro D**. It currently runs on many lines in Germany and through to other countries like France.

Just like the ICE 2, the ICE 3 and the ICE 3M were developed as short trains, and are able to travel in a system where individual units run on different lines, then being coupled to travel together. Since the ICE 3 trains are the only ones able to run on the Köln – Frankfurt high-speed line with its 4.0% incline, they are used predominantly on service that utilize this line.

The high-speed line in Germany, the Erfurt – Leipzig/Halle high-speed railway, which opened in December 2015, is the most recent addition to the ICE network. It is one of the three lines in Germany (the other two are Nuremberg – Ingolstadt high – speed rail line and Cologne – Frankfurt high-speed rail line), which are equipped with a line speed of 300 km/h. Since only 3rd generation ICE trains can travel at this speed, the ICE line 41, formerly running from Essen to Nuremberg, was extended over the Nuremberg – Ingolstadt high-speed rail line. In France, the ICE 3 runs at speeds of up to 320 km/h on the LGV Est railway Strasbourg – Paris.

Fig.1.11　ICE 3

1.1.2.4 Fourth Generation ICE 4

Whereas ICE 3 has traditionally focused on increasing speed, ICE 4 (Fig.1.12) has a slightly more modest top speed and a focus on economics. Initially called ICX, it was renamed to ICE 4 in December 2015. The 12-car train ICE 4 has a total length of 346 m, a maximum speed of 250 km/h, and a total of 830 seats (205 seats in 1st class, 625 seats in 2nd class).

Fig.1.12 ICE 4

Comparison of Various Types of EMUs in Germany is shown in Tab.1.3.

Tab.1.3 Comparison of Various Types of EMUs in Germany

Type	Power/kW	V_{max} /(km/h)	Marshalling	In service
ICE 1	9600	280	2M12T	Since 1990
ICE 2	4800	280	1M7T	Since 1996
ICE 3	8000	330	4M4T	Since 2000
ICE 4	9900	250	6M6T	Since 2017

1.1.3 High Speed Trains in France

The TGV is France's intercity high-speed rail service, operated by the French National Railways. The French National Railways worked on a high-speed rail network from 1966 to 1974 and presented the project for approval. Originally it was planned for the TGV to be propelled by gas turbines, selected for their small size, good power-to-weight ratio and ability to deliver high power over an extended period. The first prototype, TGV 001, was the only gas-turbine TGV: following the oil price increase during the 1973 energy crisis, gas turbines were deemed uneconomic and the project turned to electricity from overhead lines, generated by new nuclear power stations. Changing the TGV to electric traction required a significant design overhaul. The first electric prototype, nicknamed Zébulon, was completed in 1974, and it was used to test features such as innovative body mounting of motors, pantographs, suspension and braking. Body mounting of motors allowed over 3 tonnes to be eliminated from the power cars and greatly reduced the unsprung weight. The prototype travelled almost 1 000 000 km during testing.

Following the inaugural service between Paris and Lyon in 1981 on the LGV Sud-Est (LGV for Ligne à Grande Vitesse; "high-speed line"), the network, centered on Paris, expanded to connect major cities across France including Marseille, Lille, Bordeaux, Strasbourg, Rennes and Montpellier and in neighboring countries on a combination of high-speed and conventional lines. The TGV network in France carries about 110 million passengers a year.

The high-speed tracks, maintained by the French National Railways are subject to heavy regulation. Confronted with the fact that train drivers would not be able to see signals along the track-side when trains reached full speed, engineers developed the TVM cab-signaling technology, which would later be exported worldwide. It allows for a train engaging in emergency braking to request within seconds all following trains to reduce their speed, if a driver does not react within 1.5 km, the system overrides the controls and reduces the train's speed automatically. The TVM safety mechanism enables TGVs using the same line to depart every three minutes.

A TGV test train set the world record for the fastest wheeled train, reaching a speed of 574.8 km/h, in April 2007. Conventional TGV services operate up to 320 km/h on the LGV Est, LGV Rhin-Rhône and LGV Méditerranée. In 2007, the world's fastest scheduled rail journey was a start-to-stop average speed of 279.4 km/h between the Champagne-Ardenne and Gare de Lorrain on the LGV Est, not surpassed until 2013, when the express service on the Shijiazhuang to Zhengzhou segment of China's Shijiazhuang – Wuhan high-speed railway recorded average speeds of 283.7 km/h.

The TGV system extends to neighboring countries, directly including linking (Italy, Spain, Belgium, Luxembourg and Germany) and through TGV-derivative networks which links France to Switzerland, to Belgium, Germany and the Netherlands, as well as to the United Kingdom (Eurostar). Several future lines are planned, including extensions within France and to surrounding countries.

TGVs have semi-permanently coupled articulated unpowered coaches, with Jacobs bogies between the coaches supporting both of them. Power cars at each end of the trains have their own bogies. Trains can be lengthened by coupling two TGVs, using couplers hidden in the noses of the power cars. The articulated design is advantageous during a derailment, as the passenger carriages are more likely to stay upright and in line with the track. Normal trains could split at couplings and jackknife, as seen in the Eschede train disaster. A disadvantage is that it is difficult to split sets of carriages. While power cars can be removed from trains by standard uncoupling procedures, specialized depot equipment is needed to split carriages, by lifting the entire train at once. Once uncoupled, one of the carriage ends is left without a bogie at the split, so a bogie frame is required to support it. Using power cars instead of Electric Multiple Units (EMU) easily allows for a high ride quality and less electrical equipment.

There are five types of TGV equipment in use:

1.1.3.1 The TGV Atlantic (TGV-A)

The TGV Atlantic (TGV-A) is a class of high-speed trains used in France by the French National Railways, which were built by Alstom between 1988 and 1992. Numbered 301-405, the TGV-A trains were built for the opening of the LGV Atlantic (Fig.1.13). Entry into service began in 1989. TGV-A trains are 237.5-m-long and 2.904-m-wide. They weigh 444 tonnes and are made up of two power cars and ten carriages with a total of 485 seats. They were built for a maximum speed of 300 km/h with 8 800 kW total power under 25 kV.

Fig.1.13　TGV Atlantic (TGV-A)

1.1.3.2　TGV Reseau (TGV-R)

The TGV Reseau (TGV-R) trains were built by Alstom between 1992 and 1996. This model of TGV train is based on the earlier TGV Atlantic. The first TGV-R entered service in 1993. As well as using standard French voltages of AC 25 kV and DC 1 500 V, the triple voltage sets can operate under the Belgian and Italian DC 3 kV supplies.

TGV-R are formed of two power cars (8 800 kW under 25 kV – like the TGV Atlantic) and eight carriages, giving a capacity of 377 seats. They have a top speed of 320 km/h. They are 200-m-long and are 2.904-m-wide. The dual-voltage sets weigh 383 tonnes and owing to axle-load restrictions in Belgium the triple-voltage sets have a series of modifications, such as the replacement of steel with aluminum and hollow axles, to reduce the weight to under 17 tonnes per axle. Owing to early complaints of uncomfortable pressure changes when entering tunnels at high speed on the LGV Atlantic, the TGV Reseau (Fig.1.14) trainsets is pressure-sealed.

Fig.1.14　TGV Reseau (TGV-R)

1.1.3.3　TGV Duplex

The TGV Duplex (Fig.1.15) was a French high-speed train in the TGV series, manufactured by Alstom and operated by the French National Railways. It was unique among TGV trains in that it featured bi-level carriages. The TGV Duplex inaugurated the third generation of TGV trains.

TGV Duplex trains had aluminum bodies, the strict requirement of a 17-tonne axle load limit made it imperative to cut down on weight, wherever possible. Extruded aluminum construction reduce 20% of structure weight.

The nose of the power units and the gap between trailers were improved to the extent that a Duplex train cruising at a speed of 300 km/h experienced only 4% more drag than a single-level TGV.

The active pantograph, the Faiveley CX, used on the TGV Duplex had a pneumatically actuated active control system. Two small gas cylinders in the wiper armature could tune the stiffness of the pantographs upper stage, to optimize contact at any speed.

TGV Duplex trains had all wheel disc brakes, earlier TGVs (including Eurostar) used disc brakes only on unpowered axles. Weight gains on the Duplex power units allowed the installation of disc brakes directly on the wheels of powered axles, instead of using the traditional tread brakes. This did not greatly improve braking performance, but it left the wheel tread smooth and considerably reduced rolling noise.

The cooling fans in the TGV Duplex power units produced the most noticeable sound when the train was in a station. The fans, located in the roof of the unit, were redesigned to be quieter.

The Duplex was specially designed to increase capacity on high-speed lines with saturated traffic. With two seating levels and a seating capacity of 508 passengers, the TGV Duplex increased the passenger capacity. While the TGV Duplex started as a small component of the TGV fleet, it became one of the workhorses.

Fig.1.15 TGV Duplex

1.1.3.4 TGV POS

The TGV POS (POS stands for Paris – Ostfrankreich – Süddeutschland in German, which means Paris – Eastern France – Southern Germany). The POS (Fig.1.16) is a TGV trainset built by French manufacturer Alstom which is operated by the French National Railways, on France's high-speed rail lines. It was originally ordered by the French National Railways to use on the new LGV Est, which was put into service in 2007. Each TGV POS trainset is formed of eight existing TGV Reseau single-deck carriages paired with new power cars, with a total power output of 9.6 MW and a top speed of 320 km/h under 25 kV. The surplus TGV Reseau power cars have been combined with newer TGV Duplex carriages to create TGV Reseau Duplex trainsets. This is because traffic on the LGV Est is expected to be less than on the heavily congested LGV Sud-Est. The TGV POS links France to Germany and Switzerland. In Switzerland, it travels from Basel to Zurich and on the line from Vallorbe to Lausanne coming from Paris. From 2013 to 2019, all of the TGV POS trainsets operated under the TGV Lyria brand and livery (a joint-venture by French National Railways and the Swiss Federal Railways) with services between France and Switzerland, replacing the nine TGV PSE trainsets that were taken out of service.

Each TGV POS trainset weighs 383 tonnes and is numbered in the 4400 series. The livery is the same as that of TGV Reseau sets (silver and blue). Pre-production set No 4401 had a prototype livery similar as the one used on the TGV Duplex sets but, in March 2007, the blue areas were stickered over with silver and now the sets have the same appearance as other sets. Like the TGV TMST, the TGV POS power cars have asynchronous motors and, in case of failure, isolation of an individual motor in a powered bogie is possible. By using IGBT (Insulated Gate Bipolar Transistor) power packs, the new power cars are capable of developing 75% of their full rated power under 15 kV German and Swiss electrifications, compared to 45% for existing TGV power cars. This allows POS trains to operate at the same speed as Intercity-Express trains in Germany.

Fig.1.16 TGV POS

1.1.3.5 TGV Euroduplex

The TGV Euroduplex (Fig.1.17) is a high-speed double-decker electric multiple unit train manufactured by Alstom. It is primarily operated by the French National Railways and also in operation with the Moroccan National Railways.

The Euroduplex trains are interoperable, containing equipment allowing them to travel between several European continental countries with various types of electrification and signaling systems. A Moroccan variation is the first high-speed train to operate in Africa.

The Euroduplex trains are an evolution of the TGV Duplex but also keep some of the features. The drive is a similar type to the TGV POS asynchronous traction motors, and it uses the European signaling system. The trailers feature improved information systems.

The TGV Euroduplex differs from the TGV Duplex as it has: UIC (International Union of Railways) loading gauge with more headroom upstairs, improved windows, Passenger Information System (SIVE) with voice announcements as in the TER trains, outside SIVE dynamic light display indicating the number of the train, its route and the number of the car, fixed filler gaps on all doors, overall control of each axle, improved accessibility for wheelchairs. It also has new interiors that include new seat designs in both classes, rotating seats with USB sockets in first class and individual lights are now included in the seats.

Fig.1.17　TGV Euroduplex

Comparison of Various Types of EMUs in France is shown in Tab.1.4.

Tab.1.4　Comparison of Various Types of EMUs in France

Equipment type	Top speed /(km/h)	Seating capacity	Overall length/m	Width /m	Weight empty/t	Weight full/t	Power /kW	First built
TGV Atlantic	300	485	238	2.90	444	484	8 800	1988
TGV Reseau	320	377	200	2.90	383	415	8 800	1992
TGV Duplex	320	508	200	2.90	380	424	8 800	1994
TGV POS	320	361	200	2.90	383	415	9 280	2005
TGV Euroduplex	320	509/ 533	200	2.90	380	424	9 400	2011

1.1.4　High Speed Trains in China

China’s EMUs include the CRH (China Railway Highspeed) series and CR (China Railway) series. The CRH series is divided into the CRH1, CRH2, CRH3, CRH5 and other series models. The name CRHs was introduced in 2007. CRH trains are produced according to China’s actual needs on the basis of introducing foreign EMUs technology. It is an EMUs with independent innovation significance. Subsequently, CRH380 series EMUs were successively developed and manufactured. The CR series EMUs were independently developed by China in 2012 and named CR in 2017. CR trains are EMUs with independent intellectual property rights and are a bright business card for China’s high-speed rail technology export to the international market. CR EMUs include the CR400, CR300 and CR200 speed series models (including intelligent EMU).

1.1.4.1 CRH series – CRH1A platform EMUs

The CRH1A platform EMUs is manufactured in China and incorporates BSP technology from Bombardier Sifang (Qingdao) Transportation Ltd. (BST) and has speed grades of 200 km/h and 250 km/h. The CRH1A platform EMUs includes the following trainsets; CRH1A (8 Marshalling, 5M+3T), CRH1A-A (8 Marshalling, 5M+3T), CRH1B (16 Marshalling, 10M+6T) and CRH1E (sleeper EMUs, 16 Marshalling, 10M+ 6T). Some of these EMUs are shown in Fig.1.18 and Fig.1.19. CRH1A platform EMUs mainly operate in Shanghai, Jiangxi Province, Guangdong Province, Sichuan Province and other regions.

Fig.1.18 CRH1A EMUs

Fig.1.19 CRH1E EMUs

1.1.4.2 CRH series – CRH2A platform EMUs

The CRH2A platform EMUs used the Kawasaki Heavy Industry E2-1000 EMUs from Japan as its prototype. The CRH2A platform EMUs was independently innovated and developed by CRRC Qingdao Sifang Locomotive & Rolling Stock Co., Ltd. As shown in Fig.1.20. The CRH2A platform EMUs consists of the following trainsets; CRH2A (8 Marshalling, 4M+4T), CRH2B (16 Marshalling, 8M+8T), CRH2C (8 Marshalling, 6M+2T), CRH2E (sleeper EMUs, 16 Marshalling, 8M+8T), CRH2G (cold resistant, 8 Marshalling 4M+4T) and CRH2J (comprehensive inspection trains, 8 Marshalling, 4M+4T). The maximum operating speed of the CRH2C EMUs is 300 km/h and for other types of CRH2 EMUs is 250 km/h. The CRH2G is a specialized cold and sand/windstorm resistant version. This type of EMUs has been put into operation in northwest and southwest regions of China, on high-speed rail lines such as Lanzhou – Xinjiang, Xi'an – Lanzhou and Kunming – Dali – Lijiang. CRH2A platform EMUs are mainly operate in Shanxi Province, Hubei Province, Shaanxi Province, Shandong Province, Shanghai City, Jiangxi Province, Guangdong Province, Sichuan Province, Guangxi Province and Yunnan Province.

Fig.1.20 CRH2A EMUs

1.1.4.3 CRH series – CRH3 platform EMUs

The CRH3 platform EMUs is mainly manufactured by CRRC Tangshan Co., Ltd. The maximum operating speed of the CRH3A (8 Marshalling, 4M+4T) is 250 km/h. The CRH3A EMUs (Fig.1.21) is suitable for long ramp operation, mainly in Liaoning Province and Sichuan Province. The CRH3C (8 Marshalling, 4M and 4T) as the first generation of typical EMUs, was independently developed using the German ICE-3 train as a prototype and has a maximum operating speed of 350 km/h. It mainly operates on lines in Guangdong Province and Sichuan Province.

Fig.1.21　CRH3A EMUs

1.1.4.4　CRH Series – CRH5A platform EMUs

The CRH5A platform EMUs is produced by CRRC Changchun Railway Vehicles Co., Ltd. It has 8 marshalling with a maximum operating speed of 250 km/h, it includes the trainsets; CRH5A (8 Marshalling, 5M+3T), CRH5G (Fig.1.22, cold and sand/windstorm resistant, 8 Marshalling, 5M+3T), CRH5E (sleeper trains, 16 Marshalling, 10M+6T) and CRH5J (Comprehensive inspection train, 8 Marshalling, 5M+3T), which mainly operate in northern China.

Fig.1.22 CRH5G EMUs

1.1.4.5 CRH380 Series – CRH380A Platform EMUs

The CRH380A platform EMUs is a high-speed EMUs independently developed by CRRC Qingdao Sifang Locomotive & Rolling Stock Co., Ltd. using the CRH2C EMUs as a foundation and has a maximum operating speed of 350 km/h. The CRH380A platform EMUs includes the; CRH380A (8 marshalling, 6M+ 2T), CRH380AL (Fig 1.23, 16 marshalling, 14M+2T), CRH380AN (8 marshalling, 6M+2T), CRH380AJ (Comprehensive inspection train, 8 marshalling, 7M+1T) and CRH380AM (Comprehensive inspection train, 6M).

Fig.1.23 CRH380AL EMUs

1.1.4.6 CRH380 Series – CRH380B Platform EMUs

The CRH380B platform EMUs is one of the CRH380 series high-speed EMUs independently developed by CRRC Tangshan Co., Ltd. and CRRC Changchun Railway Vehicles Co., Ltd. using the CRH3C EMUs as a foundation, it includes the following trainsets; CRH 380B (8 marshalling, 4M+4T), CRH380BL (16 marshalling, 8M+8T), CRH380BG (cold resistant, 8 marshalling, 4M+4T) and CRH380BJ (comprehensive inspection train, 8M marshalling, 4M+4T) and CRH380BJ-A (cold resistant comprehensive inspection train, 8 formation, 4M+4T). The CRH380B platform EMUs has a maximum operating speed of 350 km/h and is shown in Fig.1.24. The CRH380BG EMUs is a cold resistant EMUs independently developed by CRRC Changchun Railway Vehicles Co., Ltd. Using the CRH380BL EMUs as a foundation.

Fig.1.24　CRH380B EMUs

1.1.4.7　CRH380 Series – CRH380C Platform EMUs

The CRH380C platform EMUs is produced by CRRC Changchun Railway Vehicles Co., Ltd. and is a type of CRH380CL EMUs (16 marshalling, 8M+8T), with a maximum operating speed of 350 km/h, which is shown in Fig.1.25.

Fig.1.25 CRH380CL EMUs

1.1.4.8 CRH380 Series – CRH380D Platform EMUs

The CRH380D platform EMUs is a CRH380 series high speed EMUs developed by Bombardier Sifang (Qingdao) Transportation Ltd. (BST). It is a type of CRH380D EMUs (8 marshalling, 4M+4T). Its highest operating speed is 350 km/h and is shown in Fig.1.26.

Fig.1.26 CRH380D EMUs

1.1.4.9 CR Series

CR series EMUs are Chinese Standard EMUs developed by the China State Railway Group Co., Ltd., with completely independent intellectual property rights and are some of the most technologically advanced EMUs in the world. The CR400 EMUs is currently the highest operating high-speed train in the world. CR series EMUs include the CR400, CR300 and CR200. 400 means the EMUs has been designed to operate at the speed of 300 to 400 km/h, 300 means the EMUs has been designed to operate at the speed of 200 to 300 km/h; 200 means the EMUs has been designed to operate at the speed of 100 to 200 km/h.

In June 2017, China's standard EMUs was officially named "Fuxing Hao" and began operating on the Beijing – Shanghai, Beijing – Tianjin, Beijing – Guangzhou, Shanghai – Nanjing and other high-speed railway lines. In order to meet the transportation needs of large passenger flow trunk lines, 16 and 17 marshalling "Fuxing Hao" EMUs have been put into operation one after another.

1.1.4.10 CR Series – CR400 platform EMUs

The CR400 platform EMUs is divided into two platforms: the CR400AF platform EMUs and the CR400BF platform EMUs. The CR400AF platform EMUs is designed by CRRC Qingdao Sifang Locomotive & Rolling Stock Co., Ltd., and manufactured by CRRC

Qingdao Sifang Locomotive & Rolling Stock Co., Ltd. and BST Company respectively. It includes the CR400AF (8marshallings, 4M+4T), CR400AF-A (16marshallings, 8M+8T), CR400AF-B (17marshallings, 8M+9T) and CR400AF-G (cold resistant, 8marshallings 4M+4T) EMUs. The CR400BF platform EMUs is designed by CRRC Changchun Railway Vehicles Co., Ltd. and manufactured by CRRC Changchun Railway Vehicles Co., Ltd. and CRRC Tangshan Co., Ltd. It includes the CR400BF-B (17marshallings, 8M+9T) and CR400BF-G (cold resistant, 8marshallings, 4M+4T). CR400AF and CR400BF platform EMUs can achieve interconnection.

CR400AF EMUs and CR400BF EMUs are shown as in Fig.1.27.

Fig.1.27 CR400AF EMUs and CR400BF EMUs

1.1.4.11 CR Series – CR300 platform EMUs

On the basis of the successful development of the CR400 “FuXing Hao” with a speed of 350 km/h, China continued to develop the CR300 “FuXing Hao” EMUs with a speed of 250 km/h. In November 2019, CRRC Qingdao Sifang Locomotive & Rolling Stock Co., Ltd. and CRRC Changchun Railway Vehicles Co., Ltd. obtained the model license and manufacturing license of CR300AF (8marshallings, 4M+4T) and CR300BF (8marshallings, 4M+4T) “Fuxing Hao” with a speed of 250km/h issued by China State Railway Group Co., Ltd, as shown in Fig.1.28. It has been put into operation in the regional railway network passenger dedicated line.

Fig.1.28 CR300AF EMUs (left) and CR400BF EMUs (right)

1.1.4.12 CR Series – CR200J EMUs

The difference between the CR200J EMUs and the above EMUs is that the CR200J EMUs is a power centralized EMUs. Power centralized EMUs are also an important part of the "Fuxing Hao" EMUs series. The 160 km/h power centralized EMUs is widely used on existing lines in China, and the CR200J can operate normally at a speed of 160 km/h on Passenger Dedicated Lines (PDL) with the a speed limit of over 200 km/h. Both ends of the CR200J are equipped with cabs. CR200J EMUs are divided into long and short marshaling in which the long marshalling train is 11-20marshalings (2M+(9~18)T), and the short marshalling train is 9marshalings (1M+9T). The CR200J is jointly produced by CRRC Tangshan Co., Ltd., CRRC Puzhen Co., Ltd., CRRC Changchun Railway Vehicles Co., Ltd. and CRRC Qingdao Sifang Locomotive & Rolling Stock Co., Ltd.

1.2 Types of EMUs

1.2.1 Classification by Traction Power Type

According to the type of traction power, trains are divided into electric multiple units (EMUs), diesel multiple units (DMUs), hybrid trains (EEMUs&DEMUs) and maglev trains.

1. EMUs

EMUs refer to trains running on electrified railways. Because the electric power is extracted from the outside as the energy source, the power structure is omitted, so the electric traction has the advantages of large traction power, light axle weight, good economy, and environmental protection. Thus 80% of high-speed railways across the world use electric traction. China's high-speed EMUs have absolute advantages in the world in terms of quantity and quality, and the proportion of electrified traction is higher in China than in ofher countries. The EMUs mentioned in this book are electric power decentralized multiple units.

2. DMUs

DMUs refers to a train driven by an internal combustion engine. According to the type of internal combustion engine, it can also be divided into diesel train and gas turbine train. The vast majority of China's railway diesel trains are DMUs. DMUs have the advantages of low investment and quick results, so they are usually used in high-speed railway sections that have not yet been electrified or as a bridge for the development of high-speed railway construction. At present, DMUs are rarely used in China, and Passenger Dedicated Lines are not used.

3. Hybrid trains

Hybrid trains are driven by a variety of motive power sources (catenary, battery, internal combustion engine). They can meet the needs of cross-line operation from electrified railways to non-electrified railways, providing passengers with convenient travel. Hybrid trains include; battery-electric catenary-powered (EEMU) and catenary-powered internal combustion engine (DEMU). At present, hybrid trains have not been officially put into commercial operation in China.

4. Maglev trains

Maglev trains are not used on a large scale. They use electromagnetic system to suspend the whole train on a guide rail and use a linear motor to directly convert the electric energy into traction force to drive the train to run at high speed. Maglev trains are suitable for ultra-high-speed operation because the wheels and rails do not make contact and have no frictional resistance. The top speed of a maglev train is over 500 km/h, and its maximum test speed is 581 km/h. At present, China has successfully introduced low-speed maglev trains into commercial operation and high-speed maglev trains are still under development and testing.

1.2.2 Classification by Power Distribution Method

The power distribution method refers to the number and location of power units in the EMUs marshalling. EMUs can be divided into power centralized and power decentralized according to their power distribution method.

1. Power centralized EMUs

In EMUs marshalling, the power distribution method with power units at both ends (or power unit at one end and control unit at the other end) and trailers in the middle is called power centralized EMUs. The utility model is characterized in that the power units at both ends are a complete power unit, which is different from the traditional centralized power locomotive, which can only traction without carrying passengers. The power unit and the control unit can properly accommodate the drivers and passengers. The control unit is also equipped with a driver's cab, the driver's cab has an aerodynamic design.

Compared with a power decentralized train, a power centralized train has a lighter power unit and it is easier to maintain, but the disadvantage is that the motor train has a larger axle load. The CR200 series EMUs in China, TGV Series in France and ICE1, ICE2 series in Germany are all power centralized trains.

2. Power decentralized EMUs

The power distribution method of power decentralized EMUs means that all cars are power cars, or some are power cars and the others are trailers. Power units are formed by two or more cars (as shown in Fig.1.29) and the power wheels driven by the motor are distributed under all or some of the cars. The transformers and converters in the power unit are suspended in different places. Under the car, the power unit can also be hung on the lower part of the train, so that the axle load of the EMUs is relatively uniform, and the entire EMUs can be composed of several power units.

Compared with the power centralized EMUs, the power decentralized EMUs have the following advantages: they are composed of multiple power units and have a high redundancy; the number of powered axles is large, the adhesion requirement is low and they are less affected by environmental conditions and climate; the traction equipment is installed under the floor, the axle weight is light and evenly distributed and they have little impact on the railways. On the other hand, there are also disadvantages such as a large number of power units and a large amount of maintenance.

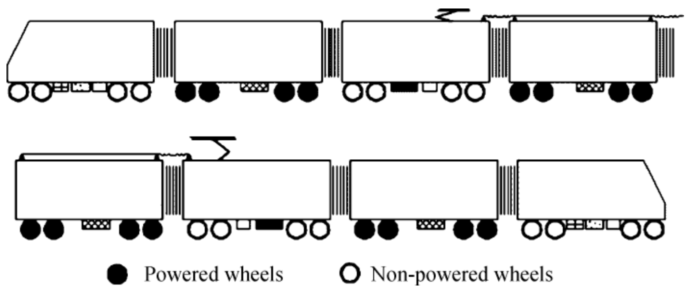

Fig.1.29 Power Decentralized EMUs

1.2.3 Classification by Speed Class

According to speed class, an EMUs can be divided into ordinary speed, fast, high-speed and ultra-high-speed.

(1) Ordinary Speed EMUs: Operating speed of 80 – 160 km/h; are used in subways, existing lines, mixed passenger and freight lines and suburban lines.

(2) Fast EMUs: Operating speed of 160 – 200 km/h; are mainly used in intercity railways.

(3) High-speed EMUs: Operating speed of 200 – 400 km/h; further subdivided into 200 – 250 km/h, 300 – 400 km/h passenger dedicated lines, which are used in regional railway network and passenger dedicated lines.

(4) Ultra-high-speed EMUs: Top speed is greater than 400 km/h in the next step of development, trial operation and planning. Such as the maglev train.

1.2.4 Classification by EMUs Bogie Type

EMUs are classified according to the type of bogie they use. There are two types of bogie: the independent bogie and the Jacobs bogie as shown in Fig.1.30.

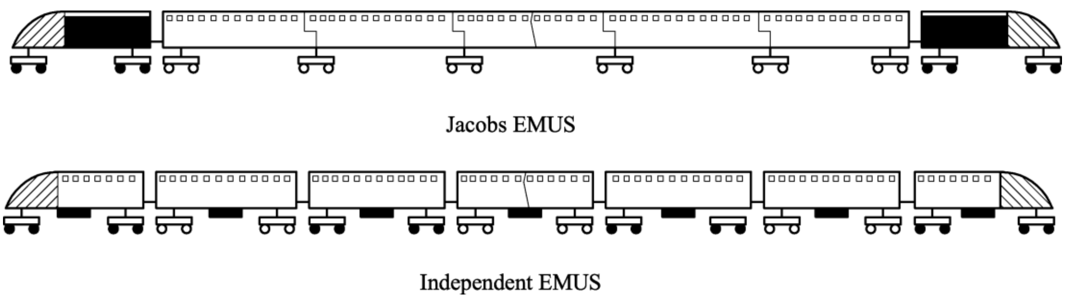

Fig.1.30 Classification by EMUs Bogie Type

Independent EMUs: The train body of each carriage is supported by two bogies, and the carriages are connected by a coupling part. After the EMUs is disassembled, the carriage can move independently. Therefore, the independent EMUs is convenient for maintenance.

Jacobs EMUs: The bogies of Jacobs EMUs are placed between two carriages. The weight of each carriage is spread across the Jacobs bogie. This arrangement provides the smooth ride of bogie carriages without the additional weight and drag. The advantages of Jacobs EMUs are: safety, because the trains are less prone to collapse like an accordion after derailing; lower weight and simpler and cheaper construction because bogies are heavy, expensive and complex structures, less rail squeal and other wheel-to-rail noise because of fewer bogies. French TGV trains are Jacobs EMUs, and China high-speed trains are independent EMUs.

There are many classification methods for EMUs. In practical application, EMUs often have the respective characteristics of the above classifications. The naming of EMUs also includes multi-parameter factors such as speed grade, enterprise identification code, technical specification code, technology type code, etc. The naming method for EMUs is described in the next section.

1.3 EMUs Numbering Rules in China

There are many types of EMUs and the number of EMUs and the naming of EMUs types need to be standardized in a complete way. Fig.1.31 shows the numbering of EMUs in China.

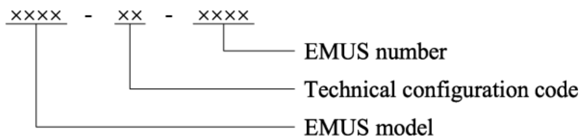

Fig.1.31　Numbering of EMUs in China

1.3.1　EMUs Models

The naming method of Chinese EMUs models in the CR series and CRH series is generally similar, but there are a few differences. They are introduced below.

1. EMUs models in CR series

The model and technical specification codes of EMUs in the CR series are shown in Fig.1.32.

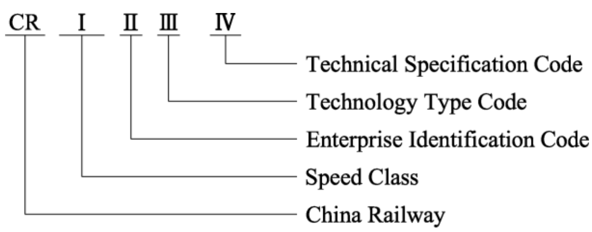

Fig.1.32　Model and Technical Specification Codes of CR EMUs Series

Ⅰ: Speed class - represented by three Arabic numerals, for example; 400 - means the design running speed is 300 to 400 km/h; 300 - means the design running speed is 200 to 300 km/h; 200 - means the design running speed is 100 to 200 km/h.

Ⅱ: Enterprise identification code - represented by one uppercase English letter and arranged in order starting from A. A represents the EMUs developed by CRRC Qingdao Sifang Locomotive & Rolling Stock Co., Ltd. B represents the EMUs developed by CRRC Changchun Railway Vehicles Co., Ltd. the rest of the letters are reserved.

Ⅲ: Technology type code - represented by a single capital letter, such as F, J, N, P and other letters: F stands for power decentralized EMUs; J stands for power centralized EMUs; N stands for power centralized internal combustion EMUs; P stands for power decentralized internal-combustion EMUs. The rest of the letters are reserved.

Ⅳ: Technical specification code - represented by one to two capital letters. The technical specification code of the basic product of each model is default and the other technical specification codes are arranged starting from A. It is a general improved product to distinguish different marshalling types, different capacity, different EMUs types and the adaptability of the same model.

2. EMUs models in CRH series

The model and technical specification codes of CRH EMUs series are shown in Fig.1.33.

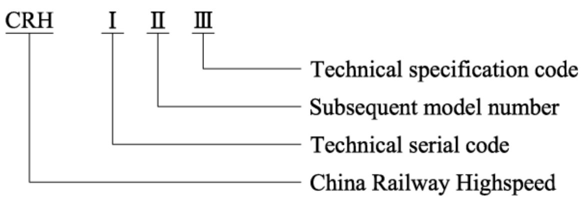

Fig.1.33 Model and Technical Specification Codes of CR EMUs Series

Ⅰ: Technical serial code - represented by Arabic numerals, arranged in order starting from 1. Used to represent the enterprise of EMUs. 1 refers to the EMUs developed by Bombardier Sifang (Qingdao) Transportation Ltd. 2 refers to the EMUs developed by CRRC Qingdao Sifang Locomotive & Rolling Stock Co., Ltd. 3 refers to the EMUs developed by CRRC Tangshan Co., Ltd. 5 refers to the EMUs developed by CRRC Changchun Railway Vehicles Co., Ltd. 6 refers to the intercity EMUs developed by CRRC Qingdao Sifang Locomotive & Rolling Stock Co., Ltd. / CRRC Puzhen Co., Ltd., 7 and subsequent numbers refer to reserved EMUs technical serial code.

Ⅱ: Subsequent model number - represented by one uppercase English letter and arranged in order starting with A. A represents a speed of 200-250 km/h, 8 marshalling with semi-cushioned seats. B represents a speed of 200-250 km/h, 16 marshalling with semi-cushioned seats. C represents a speed of 300-350 km/h, 8 marshalling with semi-cushioned seats. D represents a speed of 300-350 km/h, 16 marshalling with semi-cushioned seats. E represents a speed of 200-250 km/h, 16 marshalling with sleeper. F represents a speed of 160 km/h, 8 marshalling intercity EMUs. G represents a speed of 200-250 km/h, 8 marshalling with cold resistant EMUs. H reserved; I reserved; J represents a comprehensive inspection EMUs. K and subsequent letters reserved subsequent model numbers of EMUs.

Ⅲ: Technical specification code - represented by one to two capital letters, arranged starting with A, to distinguish different technical specification under the same basic model. The technical specification code of each basic model can be defaulted.

1.3.2 EMUs Carriage Number

EMUs carriage numbers include a carriage code, manufacturers serial number and marshalling sequence code, as shown in Fig.1.34.

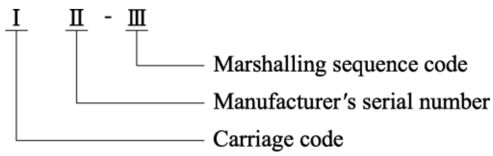

Fig.1.34 EMUs Carriage Number

Ⅰ: The carriage code of EMUs indicates the type of carriage. The carriage code of EMUs is usually an abbreviation from Chinese pinyin. The carriages are classified according to their functions, as shown in Tab.1.5.

Tab.1.5 Carriage Classification According to Function

No.	carriage code	meaning
1	ZY	First Class Coach
2	ZE	Second Class Coach
3	WR	Soft Sleeper Coach
4	WY	Hard Sleeper Coach
5	CA	Dining Coach
6	SW	Business Coach
7	ZEC	Second Class/Dining Coach
8	ZYS	First Class/Business Coach

Continue

No.	carriage code	meaning
9	ZES	Second Class/ Business Coach
10	ZYT	First Class/ Premier Coach
11	ZET	Second Class/ Premier Coach
12	JC	Detection train
13	WRC	Soft Sleeper/Dining Coach
14	WG	Luxury Sleeper coach

Ⅱ: The manufacturers serial number indicates the manufacturer and model of the EMUs carriage. The manufactures serial number is usually represented by four Arabic numerals.

Ⅲ: The marshalling sequence code is represented by two Arabic numerals and the codes from the first carriage, the second carriage to the last carriage are 01, 02 etc . There are 8 short marshalling and 16 long marshalling.

1.4 Components of EMUs

According to the specific functions of each part, the general EMUs consists of the following 8 parts: car body, bogie, traction drive and control system, braking device, end connection device, current collection device, interior equipment and train network control system as shown in Fig.1.35. Among them the car body, bogie and end connection device can be classified as the mechanical components of the EMUs. Its structure and maintenance will be introduced in detail in the next three chapters.

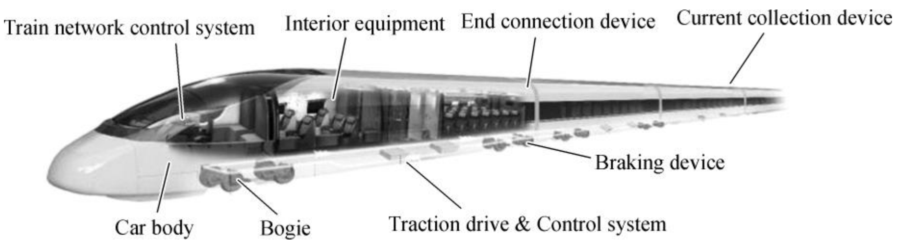

Fig.1.35 Components of EMUs

1.4.1 Car body

The car body is the part that accommodates passengers and their luggage. It is also the place where drivers cabs are located. In addition, the foundation and skeleton for installing and connecting other equipment and components can be found here, such as seat lighting equipment, sanitary facilities and air conditioning systems.

The car body usually consists of the chassis, end walls, side walls and roof and other parts. EMUs consist of two types of car body: the driver's cab and driverless car. The function of the car body is to provide passengers with a comfortable seating and standing space and to carry the train components as well as to contain the longitudinal connection load.

Modern EMUs car bodies are required to meet strength and stiffness standards while being as light as possible. Therefore, the main body is constructed with stainless steel and aluminum alloy. At this stage, carbon fiber is being tested by certain manufacturers.

Car Body Manufacturing Plant is shown as in Fig.1.36.

Fig.1.36 Car Body Manufacturing Plant

1.4.2 Bogie

Bogies are located at the lowermost part of an EMUs, between the car body and the track. They pull and guide the EMUs to travel along the track and bear and transmit various loads from the car body and the track easing its power effect; they are a key component to ensure the quality of EMUs operation and ensure the safety of operation.

Bogies are divided into motor bogies (Fig.1.37) and trailer bogies and their functions are load-bearing, guiding, damping and braking. The motor bogie also has a traction drive function.

The bogie is generally composed of a frame, a spring suspension device, a wheel set axle box device and a basic brake device. For the motor bogie, a drive device (including a traction motor and a transmission gear) is also installed.

Fig.1.37 Motor Bogie

1.4.3 Traction Drive and Control System

The traction drive and control system of the EMUs mainly refers to the electrical equipment and control circuits of the EMUs.

The function of the traction drive and control system is to realize the efficient transmission and conversion of electric energy, drive the train forward and control the normal operation of the train.

Generally, traction drive and control systems can be divided into three parts: main drive circuit system, auxiliary circuit system, electronic and control circuit system.

The main drive circuit system consists of 2 power units, each power unit consists of 1 traction transformer, 2 traction converters and 8 traction motors, each traction converter drives 4 traction motors. When the main drive circuit system fails, the single-vehicle traction or a single traction unit can be cut off without affecting other traction work. The cut off power can also be cut off by activating the high voltage isolating switch. The main drive circuit system is shown in Fig.1.38. The auxiliary circuit system components mainly include: charger, battery, electrical connector, switchboard layout and equipment, splitting phase detection system, 220 V load socket and single-phase inverter power supply, external power supply connector box, control load circuit junction box, DC 24 V power supply, fuse relay, under-vehicle insulation temperature relay, external power socket for rescue, etc. The electronic and control circuit system mainly includes various control devices related to the traction drive system.

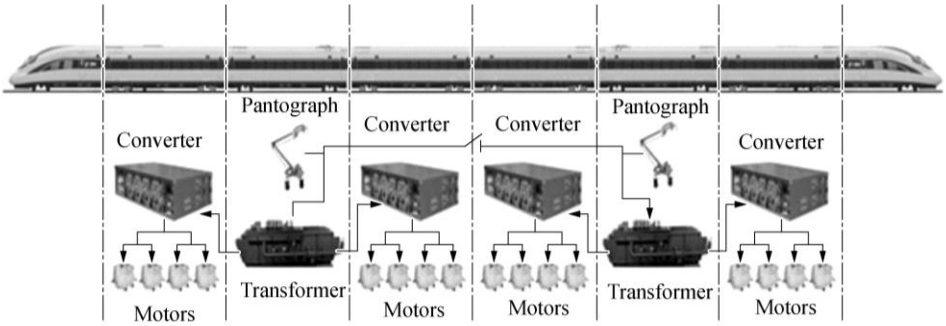

Fig.1.38 Main Drive Circuit System

1.4.4 Braking Device

The braking device includes a mechanical part, an air line part and an electric control part. Its role is to generate a certain braking force, so that the train decelerates or stops within a specified distance or time.

The braking device is an indispensable device to ensure the safe operation of the train. The braking device is not only found on the motor units, but also the trailer, so that the EMUs can be decelerated as required or parked within a prescribed distance. EMUs usually use two types of braking electric and air. Electric braking involves the conversion of the EMUs kinetic energy into electric energy by cutting the magnetic field line of the motor and then consuming the electric energy through the connection resistance to achieve braking. Since there is no physical contact, electric braking is very low cost and is the first choice of braking method. However, electric braking isn't very effective on EMUs at very low and high speeds. Air braking uses compressed air as a power source to push a friction block against the brake disc to achieve braking. But because of the physical contact, the cost is higher, due to increased wear and tear. Modern EMUs usually use electro-pneumatic braking as shown in Fig.1.39.

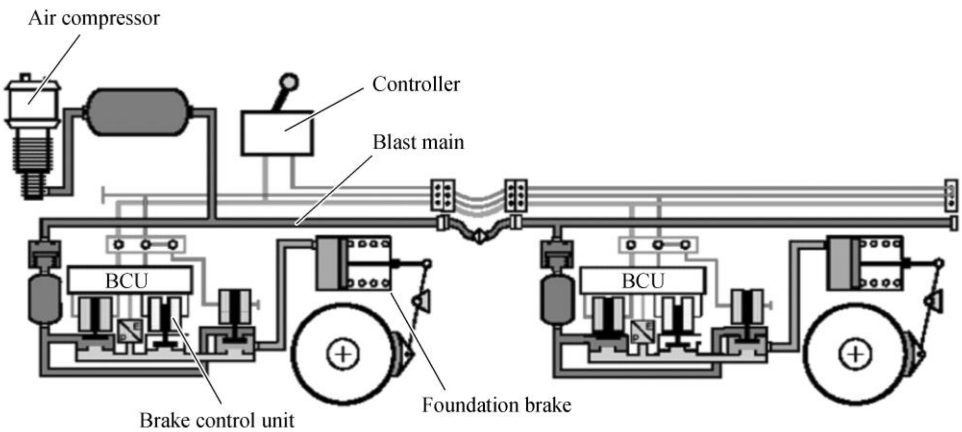

Fig.1.39 Electro-Pneumatic Braking

1.4.5 End Connection Device

The end connection device includes various coupler buffer devices, articulated devices and gangways, etc. The function of the end connection device is to couple cars, ease longitudinal impact, and transmit power and signals.

Generally, cars are organized into trains using couplers to connect each car as shown in Fig.1.40. However, articulated EMUs usually use articulated devices instead of couplers.

In order to improve the longitudinal stability of the EMUs, a buffer device is generally installed at the rear of the coupler to alleviate the impact of the EMUs. In addition, the electrical and air lines between the coaches must be well connected by means of simple and reliable connectors.

At the same time, in order to improve the sealing condition and air resistance of the train, it is necessary to adopt the use of inner and outer angways that are sealed and have a smooth transition on the outer surface.

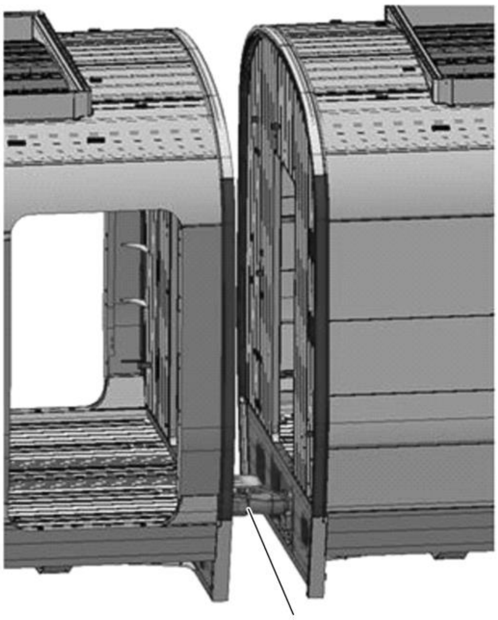

Fig.1.40 Semi-permanent Coupler

1.4.6 Current Collection Device

The current collection device collects electric current and sends it to the traction motor.

Current collection devices can be divided into various types according to the current collecting method. High-speed trains usually use the pantograph as their current collection device, this is called upper current collection. Whereas subway trains use a third rail current collector this is called lower current collection. The pantograph can be raised and lowered as needed as shown in Fig.1.41.

In terms of the current collection device standard of high-speed trains all over the world some countries use a 1500 V DC power supply (such as Japan, Malaysia, etc.), some countries use a 3000 V DC power supply (such as: Italy, Spain, etc.), other countries use a low-frequency AC power supply (such as: Germany, Switzerland, etc.) and some countries use a industrial frequency AC power supply (such as: France, the United Kingdom, etc). All passenger dedicated lines in China use 50 Hz, 25 kV single-phase AC power supply.

Fig.1.41 Pantograph

1.4.7 Interior Equipment

The function of interior equipment is to ensure the safety and comfort of passengers and the normal operation of the main equipment. Interior equipment includes fixtures in the car body for passengers and auxiliary equipment for EMUs operation.

The fixtures in the car body include: electricity, ventilation, heating, air conditioning, seats and handles, and passenger information systems.

Auxiliary equipment serving EMUs operation includes: battery box, relay box, main control box, air compressor, main air cylinder, auxiliary power supply device, various electrical switches and contactors, etc.

Layout of Air Conditioning and Ventilation System is shown in Fig.1.42.

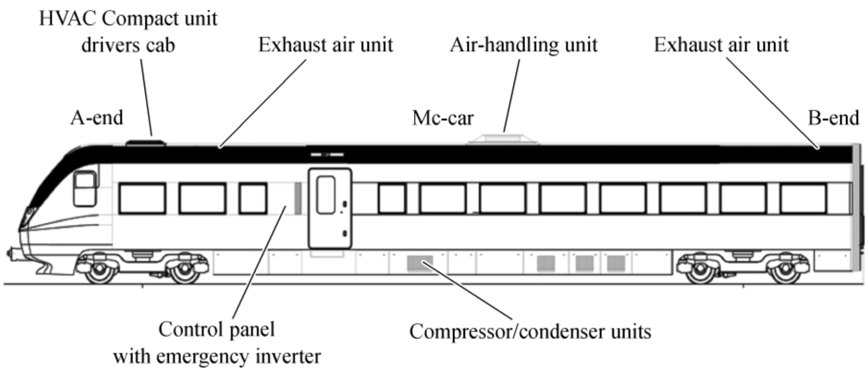

Fig.1.42　Layout of Air Conditioning and Ventilation System

1.4.8　Train Network Control System

The train communication and control system together with the subsystems and the conventional circuit technology (safety loops, train control lines) form the overall network train control system.

The train network control system is like the “brain and nerves” of the high speed train. It can provide guidance on operation to drivers and train attendants, as well as provide support for equipment maintenance and passenger services.

The function of the train network control system is to control, monitor and diagnose the traction, braking and all other equipment on the train.

The main components of the train network control system are the central control unit module, gateway module, input and output module, event recording module, repeater module, Ethernet switch module and human-computer interaction display module.

Homework

1. What are the classification methods of EMUs? Please briefly describe each.
2. How many technology platforms can China’s existing EMUs be divided into?

3. Please briefly describe the meaning of the model and technical configuration code of Chinese standard EMUs.

4. What is a power decentralized EMUs?

5. Briefly describe the meaning of the EMUs name of the CR300BF-3006 .

6. What are the components of an EMUs?