RAILWAY VEHICLE MAINTENANCE MECHANIC BASIC COURSE

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High-Speed TrainING

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Table of Contents

TABLE OF FIGURES

Summary

The aim of this training and course note is to ensure that railway vehicle maintenance and repair workers working in Railway Vehicle Maintenance units receive appropriate specialized training. It is prepared to teach basic railway terms to the personnel who will perform maintenance and repair of railway vehicles, to increase awareness about railway safety, to increase awareness about OHS, to have knowledge about railway infrastructure, superstructure, railway related legal regulations and international organizations, railway towed and towed vehicles.

CHAPTER-1 GENERAL RAILROAD INFORMATION

1 Railway Sector Structure

1.1 Historical Development of Rail Systems in the World

The French Revolution brought the industrial revolution together and as a natural consequence of this, production increased with factoryization, meeting raw material needs and marketing of finished and semi-finished products made transportation compulsory. The invention of the steam engine has made transportation both easy and cheap. In 1769, French Nicolas Cugnot and in 1786, British William Murdock tried steam power in land transportation, and in 1801, Richard Trevichick tried the steam-powered locomotive on the railway. However, the fact that the iron rails used were easily broken under the weight of the locomotive and the material used in locomotive construction was not durable prevented the development of railways.

The main development in this field was realized by George Stephenson. Stephenson succeeded in building more robust rails and locomotives, followed by the construction of the line connecting Darlington mine to the port. This success aroused great interest in England, and after the construction of the locomotive called -ROKET‖ in 1829, Stephenson was offered to build the Liverpol - Manchester line. These developments disturbed the owners of horse-drawn carriages, water transportation and the owners of the land through which the line would pass, and despite all the obstacles of these groups, the Liverpol - Manchester line was opened for operation on September 15, 1830. In the following years, we see that other Western countries also started to build railroads. In France, the first railway line was built between St. Etienne and Lyon in 1832, in Germany between Nuremberg and Frankfurt in 1835, and in Belgium between Brussels and Malines in 1835. In 1852, there were only three cities in England that had not been reached by railroads. The world started to shrink in the 19th century through railways, and each point reached became an element that enabled the development of industrialization. Developed countries started to build railroads both in their own countries and in what are now called third world countries (colonies or sub-colonies of the time). The country that built the railroad opened up even the remotest parts of that country to its own capital. Although built for different purposes, railroads have rapidly spread around the world. As a matter of fact, the length of the world railways, which was 38,600 km in 1850, reached 108,000 km in 1860, 209,000 km in 1870, 372,500 km in 1880, 612,200 km in 1890, 860,000 km in 1905 and 1,110,000 km in 1913 (Megep 2011).

1.2 Organizations Leading Railways in the World

1.2.1 European union agency for railways (ERA)

According to 2016/796/EU, the IOD program is owned by ERA. The ERA is the legal authority responsible for the EU railway system in each Member State and takes into account the enlargement of the EU and the specific limitations of rail connections with countries outside Europe.

1.2.2 NB-Rail

The NB-Rail coordination group was established for notified bodies working within the scope of IOD in accordance with Article 44 of 2016/797/EU.

The main objective of the NB-Rail coordination group is to discuss issues related to the implementation of TSIs, the application of conformity assessment methods or their compliance with the interoperability components and the proof of subsystems. These issues are defined by notified bodies, manufacturers of railway products, railway undertakings (RU), infrastructure managers (IM) or national safety authorities (NSA).

As a result of these discussions, NB-Rail publishes recommendations, guidelines, working papers and answers to frequently asked questions to ensure that the existing technical requirements of the IOD program are applied in the same way. If these discussions indicate that the current technical requirements applied within the legal scope should be renewed or improved by the European Commission, it notifies the European Commission.

To fulfill the defined tasks, NB-Rail implements three types of meetings:

a. General meetings

b. Strategy meetings

c. Sub-group meetings for INF, ENE, RST and CCS

Under the IOD program, all notified bodies are obliged to participate directly or indirectly in NB-Rail meetings and, as a minimum requirement, to implement NB-rail's recommendations, guidelines and working reports.

The formal working rules of the NB-Rail coordination group were approved by RISC 77 (Railway Interoperability and Safety Committee) on November 9, 2016.

1.2.3 OTIF

The Intergovernmental Organization for International Carriage by Rail (Organisation intergouvernementale pour les Transports Internationaux Ferroviaires [French]; OTIF) governs international rail transport. OTIF was established on May 1, 1985, following the Convention concerning International Carriage by Rail (COTIF). OTIF's predecessor was the Central Office for International Carriage by Rail (OCTI), established in 1893.

OTIF's mission is to promote, develop and facilitate international rail traffic. OTIF has three main areas of activity: mutual technical interoperability, dangerous goods and railway contract law.

OTIF develops common legal rules on:

- Passenger and cargo transportation contracts
- Ancillary equipment to transportation contracts, e.g. contracts for the use of wagons or infrastructure
- Dangerous goods transportation rules (applicable for 2008/68/EC directive)
- Technical requirements and technical approval procedures for rolling stock.

OTIF publishes UTP (Uniform Technical Prescriptions). These are technical specifications written to maximize interoperability and are based on COTIF's principles, objectives and procedures for the construction and operation of railway equipment.

Turkey is a member of OTIF.

1.2.4 UIC

The International Union of Railways (Union Internationale des Chemins de fer [French] UIC) is the professional and technical association of the international rail transportation industry, founded in 1922. The UIC brings together railway companies for the harmonization of railway construction and operation and the development of relevant conditions. UIC's classification and country codes identify the capabilities and ownership of rolling stock and assign each vehicle its own unique UIC number* to enable recognition (*now called European Vehicle Number (EVN)).

As a precursor to interoperability, UIC codes (or slips) define technical solutions for the standardization of railway equipment between countries. These are now known as International Railway Solution (IRS). The first copies of TSIs under the IOD partly used the UIC codes to create new standards.

UIC continues to promote universal rail transport, strives to develop and facilitate all forms of international cooperation, shares best practices and promotes interoperability, develops and publishes solutions (IRS) on issues related to railway systems.

1.2.5 CER

The Community of European Railway and Infrastructure Companies (CER) brings together nearly 70 railway undertakings (RUs), their national associations, infrastructure managers (IMs) and leasing companies. In the light of major political developments in the transport sector, CER was established in 1988 as an independent branch of UIC to create a strong link between railway companies and European railway institutions.

CER's role is to represent the interests of its members in the European policy field, in particular to support the creation of an improved commercial and legal environment for European railway undertakings and railway infrastructure companies.

1.2.6 UNIFE

UNIFE, the Association of the European Rail Supply Industry (Union des Industries Ferroviaires Européennes [French]) represents more than 100 of Europe's leading suppliers to the rail industry, from SMEs to internationally recognized companies. These suppliers are involved in the design, manufacture, maintenance and renewal of rail transport systems, subsystems, rolling stock, infrastructure and equipment such as signaling. UNIFE was founded in 1991 by the merger of three different organizations that protect the interests of their members at European and international level and actively promote railway equipment and standards worldwide.

UNIFE works to assist in the design of interoperability standards and the coordination of EU-funded technical research projects that contribute to the harmonization of railway systems.

1.2.7 IRIS

The International Railway Industry Standard (IRIS) has been developed by UNIFE since 2005 as a universal certification standard for organizations working as suppliers to the railway industry. The IRIS certification standard takes the similar standards of the aerospace and automotive industries as a model and aims to prevent businesses from being subjected to multiple management system audits.

The standard in question is known as ISO/TS 22163:2017, defines the requirements for management systems of railway organizations and is based on ISO 9001:2015. This is a standard that notified bodies working under IOD should be aware of when they undertake certification against quality management system based production assessment modules.

2. Work Safety in Railways

2.1 Duties and Responsibilities on OHS (Occupational Health and Safety)

Workers, employers and the state have duties and responsibilities on occupational health and safety to protect against occupational accidents and occupational diseases.

Worker Since his/her own health is in question, self-education in terms of knowledge and skills related to his/her profession and compliance with occupational safety rules will both protect the health of the worker and prevent him/her from being under financial responsibility. Research shows that 80-90% of occupational accidents are caused by employees' mistakes and failure to comply with the rules.

The rights, duties and responsibilities of workers can be summarized under the following headings

Using tools and material "correctly".

Caring for the health of self and others.

To comply with health and safety rules.

Reporting danger situations to the relevant authorities.

Reporting illnesses and accidents to the relevant authorities.

The right to know and the right to information.

Employer: Workplace owners are obliged to create conditions that fit the characteristics of the work done by the workers, to provide the workers with training that they cannot receive on their own, and to fulfill the obligations imposed on them by the laws against the workers and the environment. 10 - 20% of work accidents occur due to management errors. (TCDD Transportation Publications, 2016)

The rights, duties and responsibilities of employers can be summarized under the following headings

Taking health and safety precautions.

Providing training for employees.

Taking precautions about risks and protection in the workplace.

Implement general health and safety training.

Establishing a health and safety organization at the workplace.

Establish an Occupational Health and Safety Committee.

Establishing a workplace health and safety unit.

To cooperate with the workplace physician.

To cooperate with the occupational safety expert.

Monitor and implement innovations and developments.

State The state has a sanctioning feature in the world of work and labor with its power based on laws. The relevant provisions of our Constitution and the laws and regulations issued on the basis of it must be complied with by everyone concerned. In addition to the state's enforcement of legal obligations, the Ministry of Labor also carries out regulatory, guiding and educational work in working life. In business and working life, the cooperation of the relevant organizations in terms of both work peace and occupational safety yields positive results.

The rights, duties and responsibilities of the State can be summarized under the following headings.

Ensuring labor peace.

To prepare the relevant legislation.

Supporting voluntary participation.

Conducting an audit.

Providing education opportunities.

Providing technical support.

Counseling.

Legal Consequences of Occupational Accidents and Occupational Diseases

Occupational accidents claim the lives of many workers both in the world and in our country. According to the data of the International Labor Organization, approximately 300 workers die every day in the world as a result of work accidents. In our country, the situation is no different, approximately 4 employees lose their lives every day as a result of work accidents and 6 employees become permanently incapacitated (disabled).

According to the 2010 statistical data of the Ministry of Labor and Social Security, 14.4 employees out of every 100,000 employees lose their lives in Turkey. This figure is about 7 times higher than the European Union average (2.1 employees per 100,000 workers in the European Union). Sweden and the United Kingdom have the lowest number of fatal work accidents (about 1.3).

We are ranked 1st in Europe and 3rd in the world in occupational accidents. Likewise, the cost of employees who lose their lives or become permanently incapacitated (disabled) as a result of work accidents corresponds to approximately 4 percent of the gross national product. In 2013, the cost of occupational accidents and occupational diseases in Turkey is estimated at 34 billion TL.

Likewise, 5%-15% of the profits of workplaces are lost due to occupational accidents and occupational diseases.

In occupational safety, preventive actions should be taken instead of corrective actions. Precautions should be taken before an accident occurs.

An accident does not always have to result in injury or death.

This also helps us to analyze "near misses", because today "near misses" or "minor" accidents are the precursors of bigger accidents and injuries. Every accident is the result of negligence, a failure to foresee the factors leading to the accident. This highlights a lack of perception, approach and intention and is a cause for concern for the future.

Occupational Disease: It is a temporary or permanent illness, disability or mental impairment that the insured suffers due to a recurring reason or due to the conditions of the execution of the work according to the nature of the work in which the insured is employed.

According to the Regulation on Health Affairs of the Social Insurance Law, occupational diseases are categorized in five main groups.

These are;

1- Occupational diseases due to chemical causes,

2- Occupational skin diseases,

3- Occupational respiratory system diseases,

4- Occupational infectious diseases,

5- Occupational diseases caused by physical factors

We can examine the losses resulting from work accidents in 2 groups.

Apparent (Direct) Damages

Invisible (Indirect) Damages

2.1.1 Visible (direct) damages:

Direct damages include all expenses related to injury, death and loss of material as a result of a work accident.

- Machinery-equipment damage,
- Compensation payments,
- First aid costs,
- Other medical expenses
- Medical expenses,
- Medicine costs,
- Treatment costs
- Social assistance allowances.

2.1.2 Invisible (indirect) harms:

As a result of an occupational accident, which is difficult to calculate in terms of cost, it is expressed as damages that cannot be felt at first, but which show their effect in the workplace and in society due to material and moral obligations over time. These are

- Lost working day,
- Lost labor force,
- Production losses,
- It is the damage done to society.

3. Safety Culture in Railways

3.1 History of the Concept of Safety

Historically, the roots of the concept of safety go back to ancient times. In ancient times, people used various methods to live in harmony with their natural environment and ensure their physical safety. For example, hunter-gatherer societies developed defense strategies against dangerous animals and took precautions against natural disasters.

The industrial revolution was the period when awareness of the concept of safety increased the most and came to the agenda more. The industrial revolution was a period when factories emerged and industrial production accelerated. However, safety-related problems such as unsafe working conditions in factories, occupational accidents and occupational diseases also came along. During this period, standards, regulations and laws related to safety in factories were developed. It is seen that safety is more focused on physical risks and protective measures are often hardly implemented (Vincent, 2017)
.

In the 20th century, the understanding of safety has further developed and changed. The period of World Wars I and II was a period in which studies on security management and risk analysis in military fields were reflected in the field of safety. The importance of issues such as security, strategic planning, risk assessment and control measures in the military field paved the way for the transformation of the understanding of safety into a more complex and holistic approach (Hollnagel, 2014) .

3.2 Safety Concept in Railways

Railway safety is defined by the European Railway Agency (ERA) as "Railway safety is a set of measures, technologies and management systems that ensure that railway operations are carried out in a way that prevents damage to people, materials and the environment." (European Union Railways Agency, 2022) .

In the Railway Safety Regulation published by the Ministry of Transport, Maritime Affairs and Communications, it is defined as "taking necessary measures to keep unacceptable risks under control" (Ministry of Transport, Maritime Affairs and Communications, 2015)

A common thread in the definitions from these sources is that railway safety is a set of measures, technologies and management systems that prevent railway operations from causing harm to people, materials and the environment. It is also clear that railway safety includes the measures, procedures and management systems necessary for the design, construction, operation and maintenance of railway systems.

3.3 Approaches to Accidents

In order to ensure railway safety and prevent accidents, studies on accident prevention have been intensified. There are different approaches to accident prevention in the literature.

3.3.1 Domino theory

The domino theory or domino effect is a model that describes the cause-and-effect relationships of accidents. According to this theory, accidents occur as a chain of successive causes and consequences and that one accident can lead to other accidents, like a domino on a chain of successive causes and consequences.

Domino theory was first developed by Heinrich in the 1930s and was later extended by Bird, Reason and other researchers. This theory is often used to explain the complexity of accidents and the interaction of multiple factors.

Domino theory is expressed as a five-stage model, often referred to as a "domino chain":

Basic Causes: In this stage, called the basic causes of accidents, there are usually general causes such as organizational factors, management policies, work processes and cultural factors. These factors pave the way for the occurrence of accidents.

Transportation Causes (Indirect Causes): Based on the root causes, this stage includes more specific and direct causes. For example, factors such as lack of maintenance, inadequate training, lack of supervision are considered as transportation causes.

Immediate Causes: In this stage, which is called the direct causes of accidents, the factors immediately preceding the incident take place. For example, factors such as the use of faulty equipment, following the wrong procedure, carelessness are considered as immediate causes.

Accidents: Accidents themselves are considered to be the result of a domino chain. In this stage, property damage, injuries or other negative events take place.

Outcomes: In this stage, called the consequences of accidents, there are material, financial, legal or reputational consequences. These consequences can damage the reputation of the organization, lead to loss of resources and cause serious costs (Heinrich, 1959) .

Domino theory suggests that accidents occur as a chain of successive causes and consequences and that an accident can spread the effects of the previous stage to other stages. Therefore, it is necessary to identify the root causes of accidents and intervene in the early stages, eliminating at least one of the causes of the accident to prevent the occurrence of accidents (Heinrich, 1959) .

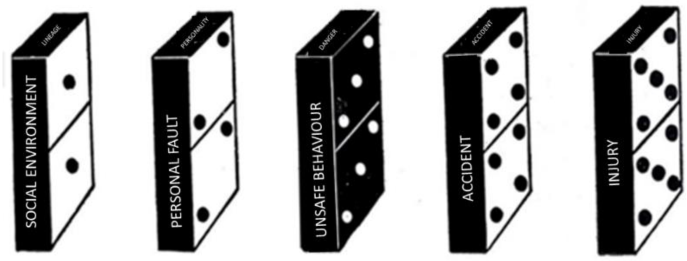


Figure 3.1 Factors causing accidents (Heinrich, 1959)

Among these emerging factors, unsafe behaviors are at the center of the factors that cause accidents. Therefore, the element that should be focused on the most in preventing accidents is the elimination of unsafe behaviors (Aktaş, 2019) .

3.3.2 Heinrich's accident pyramid

There are many studies in the literature to examine the relationships between major accidents, minor accidents and near misses that occur in enterprises. The study that has produced results that can be the basis for subsequent studies is undoubtedly the study published by Herbert W Heinrich in 1931. In this study, it was determined that in 330 incidents occurring in an enterprise; 1 major accident (involving injury or death), 29 minor accidents and 300 near misses occurred. The visual related to the study, which is included in the literature as "Heinrich's Accident Pyramid", is given in Figure 2.3 (Cooper M. , 2000) . It is also possible to understand Heinrich's accident pyramid as follows. While every major accident or 29 accidents occur in enterprises, 300 near misses occur. For this reason, in order to prevent accidents, it is necessary to examine the near misses very seriously, draw the necessary conclusions and take the necessary measures (Nam, 2019) .

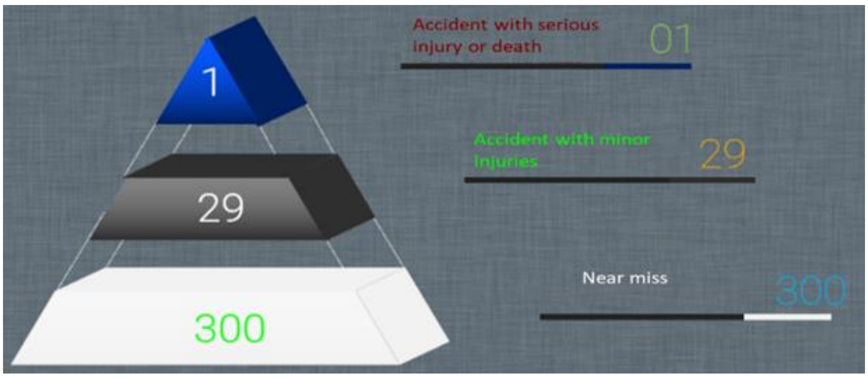


Figure 3.2 Heinrich's accident pyramid (Cooper M. , 2000)

In 1969, Frank Bird Jr. conducted a study similar to Heinrich's study. In this study, it was suggested that 10 injury accidents, 30 equipment-related accidents and 600 near-miss incidents occurred (İnci, 2016) .

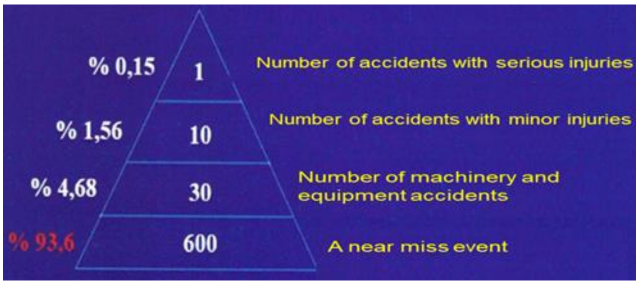


Figure 3.3 Frank Bird Jr. accident pyramid (Pişkin & Dalyan, 2020)

3.3.3 Multiple causation model

This theory, developed by Petersen in 1971, is based on the fact that managerial decisions have more influence on the occurrence of accidents than personal errors. According to Ptersen; the most important factors leading to accidents are unsafe conditions and unsafe behaviors (Hosseinian & Torghabeh, 2012) .

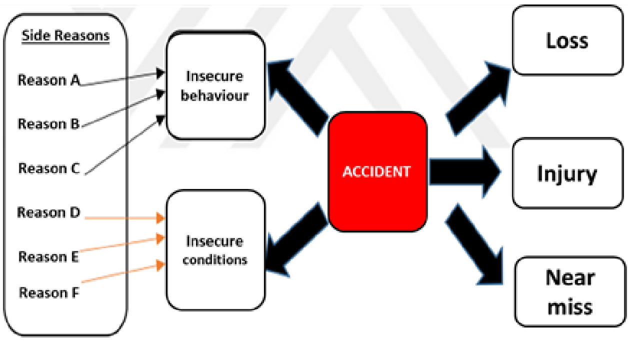


Figure 3.4 Multi-agent theory (Hosseinian & Torghabeh, 2012)

As can be seen in Figure 2.5, unsafe conditions indicate the conditions that exist in the environment before work starts. In order to eliminate accidents, unfavorable conditions must be identified and eliminated by management.

3.3.4 Human factors theory

This theory suggests that the most important element of accidents is human error, and therefore the prevention of accidents should focus on the factors that lead to human error. Therefore, the external factors that cause people to make mistakes should be investigated. These external factors can often be environmental factors and working in the wrong job. Another element that this theory draws attention to is that although people are the main cause of accidents, they should not be blamed for accidents. Instead, the environmental conditions that cause mistakes to be made should be investigated (Hamid, Majid, & Singh, 2008) .

3.4 Safety Management System (SMS)

An EMS refers to an approach that an organization adopts to continuously improve safety performance and manage safety risks. This system aims to manage safety in a holistic way by bringing together elements of the organization such as safety policy, objectives, processes, procedures and resources (Hale, Guldenmund, & Borys, 2010).

Safety management systems are a framework that enables organizations to plan, implement, audit, correct and continuously improve their safety-related activities. These systems help to improve an organization's safety performance and minimize safety risks by implementing occupational health and safety standards, regulations and best practices (Hale, Guldenmund, & Borys, 2010) .

An EMS is a holistic system formed by a number of processes or components coming together. In other words, it is the interaction of these processes or components that constitute the safety management system. Furthermore, safety management system is the monitoring and continuous improvement of safety within the organization, implementation of improvements and receiving feedbacks (DGCA, 2012) .

Figure 3.5 Organizational elements of SMS (DGCA, 2012)

3.4.1 Purpose of the safety management system

The aim of the SMS is to ensure that the organization safely controls the risks that arise as a result of its business objectives and complies with all safety obligations that apply to it (Europan Union Egency For Railway, 2020) .

Adopting a structured approach allows for the identification of hazards and the continuous management of risks related to an organization's own activities in order to prevent accidents. This approach requires continuous interaction with other actors in the railway system (mainly railway organizations, infrastructure managers and organizations responsible for maintenance, but also other actors with a potential impact on the safe operation of the rail system, e.g. manufacturers, maintenance providers, service providers, contracting authorities, carriers, shippers, consignees, receivers, loaders, unloaders, training centres, as well as passengers and other persons interacting with the rail system, etc.) (ERA, 2022) .

3.4.2 Development of safety management systems

The beginning of the development of safety management systems dates back to the 1920s when safety awareness increased. The development stages of safety management systems are briefly as follows:

The first phase covers the period from the 1920s to the 1960s and represents the period when safety was managed through a "rule and order" approach. During this period, the management of safety was based on worker training and rule-based management.

The second phase covers the period from the 1960s to the 1980s and represents the adoption of a "human errors" approach to safety. During this period, the impact of human factors and behavior on safety was emphasized and safety management focused on strategies to understand and influence human behavior.

The third phase covers the period from the 1980s to the 2000s and represents the adoption of a "systems" approach to safety. During this period, safety management focused on system-level risk assessment, process analysis and process improvement approaches (Hale, Guldenmund, & Borys, 2010)

Today, the implementation of safety management systems, such as international standards and management system models (e.g. ISO 45001:2018), is becoming increasingly common, with organizations focusing on continuously improving safety performance.

As a result, safety management systems have gone through different phases over time and approaches to the management of safety have evolved. Today, it is seen that safety is addressed within the framework of human factors, systems approach and management systems in accordance with international standards (Hale, Guldenmund, & Borys, 2010) .

3.4.3 Safety management system in railways

Safety Management System (SMS) in railways is defined in the European Union Railway Agency Safety Directive as "the organization, arrangements and procedures established by an infrastructure manager or a railway undertaking to ensure the safe management of its operations". The aim of the SMS is to ensure a high level of safety performance and continuous improvement and to limit risks in railway operations (ERA, 2022) .

Railway operators and infrastructure managers are responsible for the SMS and its safe operation, each in its own part of the system. They are required to implement the necessary risk control measures through their SMS, in cooperation with each other and other actors where appropriate (ERA, 2022) .

3.4.4 SMS applications

With the entry into force of the "Railway Safety Regulation" in Turkey, railway infrastructure companies (TCDD is the only infrastructure company in Turkey as of 2023) and transportation companies are obliged to establish SMS. Figure 2.7 shows the structure of the documentation that organizations will create for SMS.

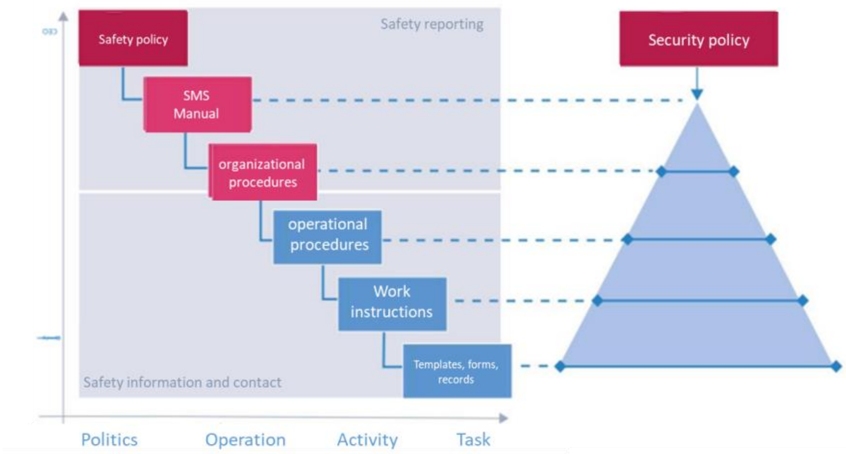


Figure 3.6 Typical documentation structure of an SMS (ERA, 2022)

According to Railway Safety Regulation, a Safety Management System is based on 5 application principles. As can be seen in Figure 2.8, these principles of implementation, also called the requirements of the SMS, are as follows (TCDD Tasımacılık AŞ Corporate Safety Management Department, 2022) :

1. Organization and distribution of authority
2. Involving all employees and representatives in the system
3. Certification of SMS components
4. Control by management
5. Continuous improvement of the system

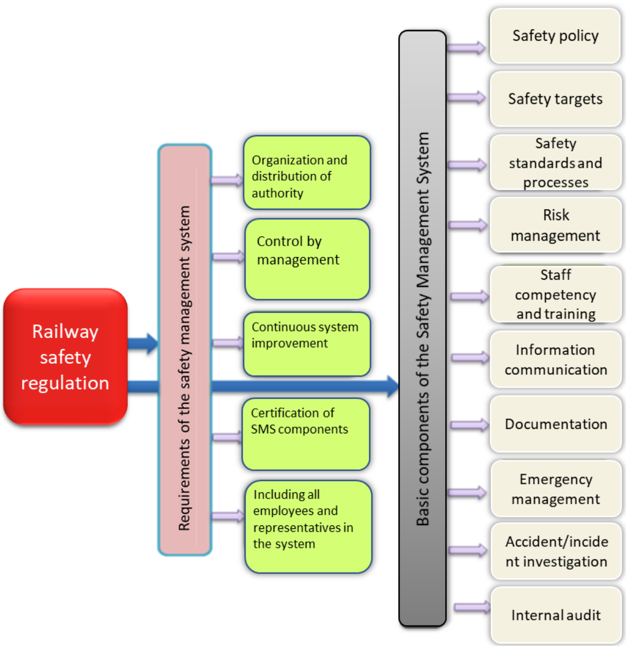


Figure 3.7 Basic implementation principles and components of SMS (TCDD Tasimacilik AS Corporate Safety Management Department, 2022)

3.4.5 SMS and process approach

An SMS is a means of bringing together the various elements that must come together to run a safe and successful organization. These elements should include mechanisms to ensure compliance with international and national regulations and standards, industry and business level requirements, the results of risk assessment and good practices within the company's operations. The SMS should therefore be integrated into the organization's business processes and should not become a paper-based system specifically developed to demonstrate compliance with the regulatory framework (ERA, 2022) .

3.5 SAFETY CULTURE ON RAILWAYS

3.5.1 Safety culture

Safety culture is the value placed on safety by all employees of the organization. Safety takes priority over all operations. The behaviors and attitudes of employees in a safety culture are always directed towards ensuring safety and maintaining safe operation (Carroll, 1998) .

Safety culture refers to those elements of culture that specifically address safety. There is no single scientific objective measurement of safety culture. This is because contributing factors vary not only between organizations, but also within them. Different departments have different safety requirements and needs, for example operational and financial, and the prevailing safety culture will develop from these. External factors such as regulatory requirements, training levels, societal structures and national culture also contribute to shaping an organization's safety culture (ERA, 2022) . Figure 3.1 shows the elements of safety culture and the scope of safety culture.

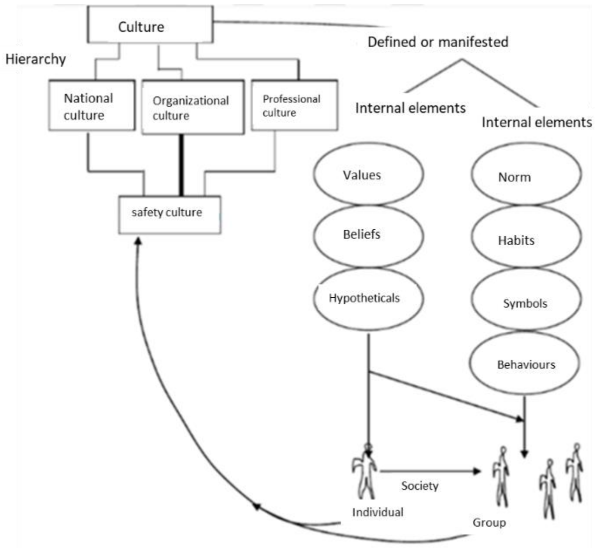


Figure 3.8 Scope of safety culture (Misnan, 2007)

An SMS provides a foundation by defining and prescribing what is required through policies and procedures. Unfortunately, a situation where a perfectly established SMS is followed to the letter by all employees is utopian. Often, management and staff try to make sense of the content of the SMS based on their values, attitudes and beliefs derived from personal experience combined with the behavioral norms of the workplace and society. If the SMS makes sense and there is a culture of compliance, the right behaviors will be followed. If not, individual interpretations will be made and alternative solutions will be applied. These will be based on an individual risk assessment that evaluates the factors that influence the decisions taken. The risk assessment will not only focus on the actual risk, but will also include factors related to compliance, the risk of getting caught, management's words and actions, etc. Therefore, the interdependence between understanding the SMS and behavior defines the safety culture (ERA, 2022) .

3.5.2 Differences between safety climate and safety culture

The concept of safety climate is often confused with the concept of safety culture in the literature.

Safety climate is defined by Zohar in his study Safety climate in industrial organizations: theoretical and applied implications as "employees' shared perceptions of the safety of the work environment". The most important factors indicating the level of safety climate are the level of management commitment to safety and the perception of safety in employees' behavior (Zohar, 1980) as seen in figure 3.2.

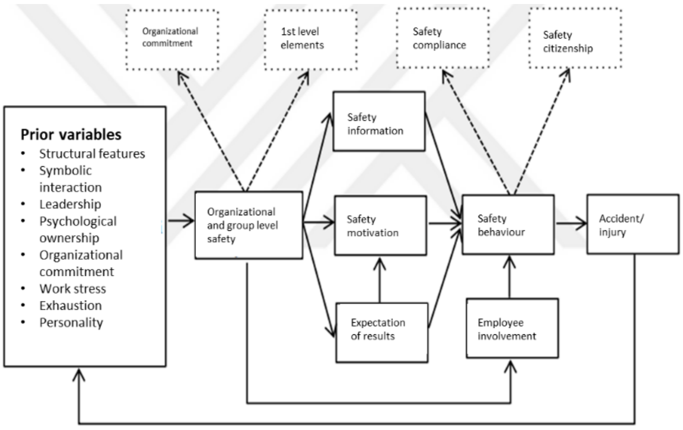


Figure 3.9 Model for conceptualizing safety climate (Zohar, Conceptualization, measurement, and improvement, 2014)

Safety climate is employees' perceptions of the documentation created to ensure safety. In other words, safety climate is how employees perceive safe working. Safety culture, on the other hand, is the attitudes and beliefs of employees that have turned into behavioral patterns in the face of risks. In this respect, safety culture is a larger concept that also includes safety climate (Yılmaz, 2019) .

As mentioned before, although the concepts of safety culture and safety climate are often confused, safety climate represents more visible perception, while safety culture represents deeper attitudes. To give an example; after railway accidents, inspections in the region where the accident occurred are increased and training activities are increased. In this case, there is a significant increase in employees' perceptions of safety. This increase represents an increase in the safety climate. It takes many more years for the safety culture to change. In another analogy, safety climate is the visible side of the iceberg while safety culture is the invisible side of the iceberg. Figure 3.3 shows the differences between safety culture and safety climate.

Figure 3.10 Differences between safety culture and safety climate (Turkish Railway Academy-TCDD, 2020)

3.6 Reason's Safety Culture Model

According to James Reason, safety culture is a concept that almost everyone uses but few people agree on its true meaning or how to measure it. Reason sees the safety culture of an organization as a model of the attitudes, behaviors and beliefs of its employees (Reason, 1998) . Safety culture refers to an organization's overall approach to safety values, norms and practices (Reason & Hobbs, 2003) .

Reason's safety culture model is a model that provides a framework for understanding the causes of human error and safety culture. The way to create an ideal safety culture is to be concerned that unsafe situations may occur continuously and to prepare for them (Reason, 1997) .

Reason mentions 5 key elements that a positive safety culture should have. These are a just culture, a reporting culture, a learning culture and a flexible culture.

Figure 3.11 Elements of safety culture (Reason, 1997)

3.6.1 Just culture

A just culture refers to a climate of trust where employees are encouraged to provide basic safety-related information and at the same time the distinction between acceptable and unacceptable behavior is clearly defined (Reason, Managing the risk of organizational accidents, 1997) . In a just culture, a deliberate violation is unacceptable, while honest mistakes are accepted. In an organization with a just culture, employees do not hesitate to admit their mistakes when they make mistakes (Dekker J. , 2007) . In this respect, just culture is also referred to as trust culture.

In a just culture, the causes of mistakes are examined and focused on root causes, and employees have the opportunity to correct systematic errors or faulty processes rather than being blamed. Based on the principles of fairness and equality, employees are treated equally and there is no discrimination or bias.

A just culture also emphasizes open communication, trustworthiness, accountability, transparency and employee participation in decision-making processes. In a culture where employees see the organization as a learning opportunity to learn from mistakes, they can openly share mistakes and contribute to the continuous improvement of the organization.

In organizations without a just culture, individuals are blamed for mistakes. This leads people to take a defensive approach, conceal information about incidents, and fail to report unsafe situations and behaviors (Dekker S. , 2003) .

In a just culture, an employee can learn from mistakes and improve by identifying and evaluating their own mistakes. In organizations with a just culture, employees are confident that they will be supported and safe when voicing their concerns. Employees can easily observe their coworkers and in case of excessive workload, they can ensure that the necessary work distribution is made to ensure safety. In a just culture, employees are confident that they will not be blamed individually in cases arising from systemic failures and that the responsibility will not be shifted to employees (Frankel, Leonard, & Denham, 2006) .

In conclusion, a just culture is an important part of a safety culture and promotes an open, honest, fair and equitable approach to handling mistakes in organizations. This enables employees to raise concerns about mistakes and enables organizations to continuously improve safety and security.

3.6.2 Reporting culture

Reporting culture, in its simplest form, refers to an organizational climate or environment in which employees are willing to report their own mistakes and potentially dangerous situations (Reason, 1997) . Reporting culture refers to an approach that encourages effective and accurate information sharing among employees of an organization or entity. By emphasizing values such as communication, collaboration, responsibility and accountability within the organization, a reporting culture can improve the performance of the organization and is a key factor for sustainable success.

In order to convince employees to report, the organization must first clearly set out the procedures and rules related to reporting, the rights and obligations of employees, and the level of protection that will be provided to employees as a result of reporting. Because it is seen that many employees are hesitant to report. The main reason for this is not that employees are dishonest, but the belief that their reports will not be evaluated by the management. In his research, Dekker found that many of the employees who do not report have thoughts like "I might get in trouble" (Dekker J. , 2007) .

3.6.3 Learning culture

Learning culture is the organization's ability to make the necessary operational changes by obtaining the right results from the experience and inputs gained through the reporting culture. Therefore, the prerequisite for the development of a learning culture is the development of a reporting culture. If the organization cannot identify situations and behaviors that pose risks and near misses, it cannot be aware of the risks and cannot make the desired operational changes on time (Reason & Hobbs, 2003) .

Learning culture is based on organizational culture and memory. Unsafe and undesirable situations directly affect the process. Statistical data and reporting are very important. Organizations can improve their organizational structures with a focus on safety by effectively using the data they obtain with the learning process (Özer & Erdem, 2022) .

When organizational actions are taken, it is necessary to check whether the actual results are in line with the desired results. If there is a mismatch, adjustments need to be made to the actions or to the underlying assumptions about the actions. Examining only actions is called single-loop learning. In this type of learning, when a mistake is made in the organization, the abnormal behaviors of the personnel who perform the actions are investigated and such actions are seen as the reasons that prevent the desired result from being achieved. This learning process ends with blaming, shaming, retraining and writing another procedure for the staff who made the mistake. Double-loop learning is the evaluation of not only the actions that led to the error but also the organizational assumptions that led to these actions. In this type of learning, it is possible to reveal how and why organizational policies, practices, structures and safety measures prevent the achievement of desired results (Ustaömer & Şengür, 2020) .

3.6.4 Flexible culture

Flexible culture refers to the ability of organizations to adapt to different situations that develop outside of regular situations. Flexible culture is a fundamental characteristic of high security organizations. In organizations with a flexible culture, it is easy to move from vertical hierarchy to horizontal hierarchy in new situations not covered by procedures. In normal working conditions, it is possible to quickly switch back to the hierarchy indicated by the procedures (Reason, 1997) .

As an example of the behavior of organizations with developed resilient cultures, the reflexes of some organizations to go into operation after the earthquakes that affected 10 provinces in Turkey on February 6, 2023 can be examined. In the post-earthquake emergency environment, the vertical hierarchy of many organizations became dysfunctional and the implementation of procedures became difficult. Organizations with a flexible culture, such as AHBAP, were able to adapt to the new situation more quickly. Some local employees took the initiative and started rescue operations without waiting for any instructions.

In summary, organizations that have developed flexible cultures can rapidly transition from centralized to decentralized management depending on operational requirements. In this transformation, activities are carried out depending on the expertise of first-line employees. The transition from centralized to decentralized management and the success of this transition is explained by the existence of a strong and disciplined hierarchical culture. This culture leads to shared values and assumptions that allow for the coordination of work groups or teams when decentralization takes place (Reason, 1997) .

3.7 ERA Safety Culture Model

Safety is a fundamental prerequisite for successful rail transportation in Europe. In almost all high-risk industries today, addressing organizational and cultural aspects has become crucial to improve safety. The success of the safety culture in these industries has convinced railway managers and legislators to adopt this philosophy across Europe.

To support the design and implementation of strategies to continuously improve the safety culture, ERA has developed the European Railway Safety Culture Model. This model is a conceptual and assessment framework that allows the user to evaluate the safety culture and identify areas for improvement.

The European railway safety culture model is a tool for understanding how safety culture develops and can be influenced. The target audience is broad and includes regulators, senior managers, railway safety managers, supervisors, researchers and all other individuals interested in the concept of safety culture. The model is built on three building blocks.

3.7.1 Building blocks and components of the European railway safety culture model

3.7.1.1 First building block: behavior models

Although there are many definitions of culture in the literature, the following general ideas constitute the definition of culture.

▶ Culture is deep-rooted, not a superficial phenomenon, and is steadily maintained over time.

▶ Culture is shared and relates primarily to a group, a community or an organization, not to an individual.

▶ Culture is broad and encompasses all aspects of external and internal relationships in a group, community or organization,

▶ Culture develops through daily interactions.

Shared assumptions, beliefs, values and norms are generally considered to be the main characteristics of any organizational culture. The iceberg model in figure 3.6, introduced by Stanley Herman in the late 1970s, shows successive layers of organizational culture.

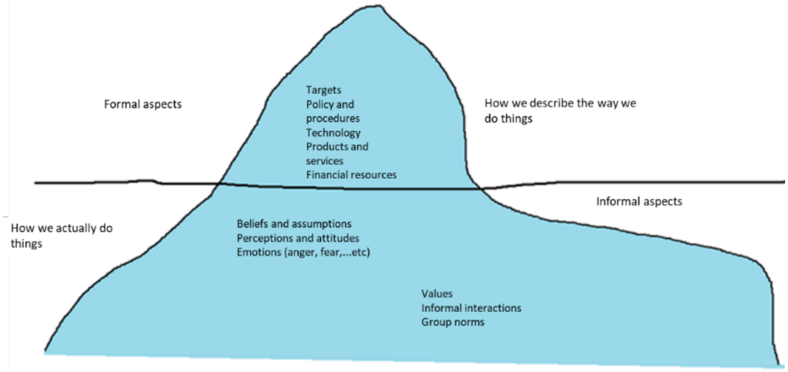


Figure 3.12 Stanley Herman's iceberg model (French & Bell, 1984)

The upper part, applied in the railway field, can be considered as the safety management system of a railway company. The effectiveness of its implementation will depend on the informal aspects specified in the lower part of the line.

Shared assumptions, beliefs, values and norms will lead individuals to behave similarly within a group. These common ways of acting and thinking are identified as "patterns of behaviour" that reflect the organizational culture and form the first building block of the European railway safety culture model.

3.7.1.2 The second building block is cultural promoters

As members of a group, individuals make sense of and interpret what they see when they encounter a certain situation. The behavior resulting from this individual interpretation is given different meanings by the members of the group. This informal dialogue among group members leads to mutual arrangements, agreements and expectations regarding each other's behavior. This stage, characterized by "interaction", constitutes the first cultural interactant.

Based on this developing shared understanding, the group begins to formalize these shared views through the distribution of tasks, roles and responsibilities, procedures and rules, as well as more physical structures and technology.

3.7.1.3 Third building block: the foundations of rail safety

It is expected that a high-risk organizational culture such as the railway sector will be shaped as a safety culture. For this reason, the European Railway Agency has identified 4 principles that form the basis of railway safety based on the models developed for high-risk sectors and the characteristics of the railway sector. These are

- Controlling major risks
- Understanding workplace realities
- Learning and continuous improvement
- Consistently integrating safety into all areas

3.7.2 Main schematic of the European railway safety culture model

Together, organizational behavior patterns, attitudes and perceptions, cultural enablers and railway safety fundamentals are the three building blocks of the model. Figure 3.7 describes the mechanism that takes place when organizational culture develops to effectively implement a safety vision based on railway safety fundamentals. Behavioural patterns shape organizational culture, which is manifested in shared ways of thinking and acting. For these patterns of behaviour to realize the four railway safety principles and lead to organizational excellence as well as safe and sustainable performance, a clear vision of how to implement it needs to be integrated across all cultural enablers. (Esen, 2023)

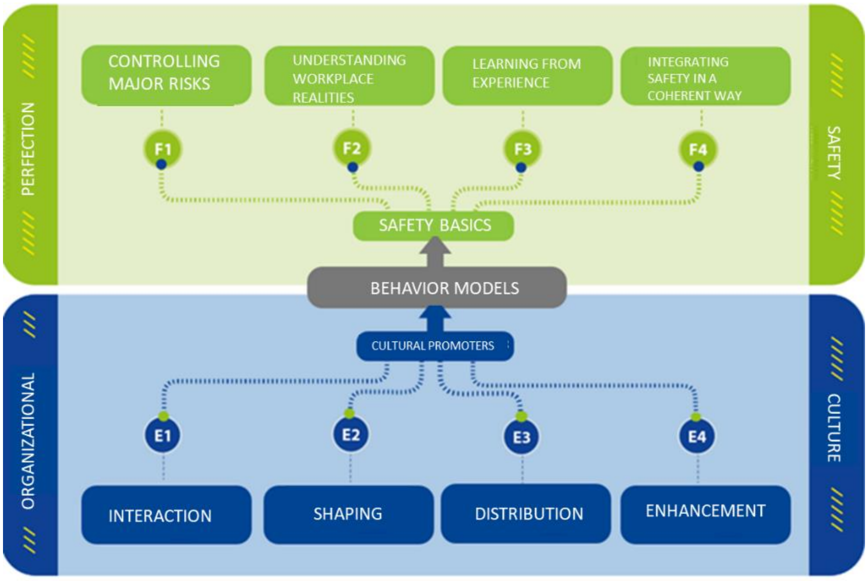


Figure 3.13 Main schematic of the European Railway Safety Culture Model (European Union Railway Agency, 2020)

SECTION:2 TOWING VEHICLE INFORMATION

4. HISTORY OF RAIL VEHICLES

The first towing vehicle of railways, one of the transportation systems, is the Steam Locomotive. In 1687, Denis Papen discovered the power of steam and James Watt found the piston steam engine. In 1801, American Oliver Evans discovered the existence of traction by utilizing the adhesion between the iron wheel and the iron rail. In 1813, Willam Hadley and Timeteus Hackwort built the first locomotive to run on rails, and George Stephenson began operating a similar machine. In 1815, George Stephenson invented the souffler for better traction of the chimney, thus doubling the power of the locomotive, and in 1830 he was able to pull a load of 17 tons at a speed of 16 km/h on a slope of 1/96, which was considered impossible at the time.

After the stages briefly described above, railroads were born and developed in a very short time and spread all over the world, starting from England, where they were born. In other words, the ancestor of the locomotives used in railways, in short, the ancestor of railway traction vehicles is the Steam Locomotive. In parallel with the natural developments of technology, diesel and electric traction vehicles were produced as a result of the development of explosion (internal combustion) engines and electric machines and their application to railways. (MEB , 2011)

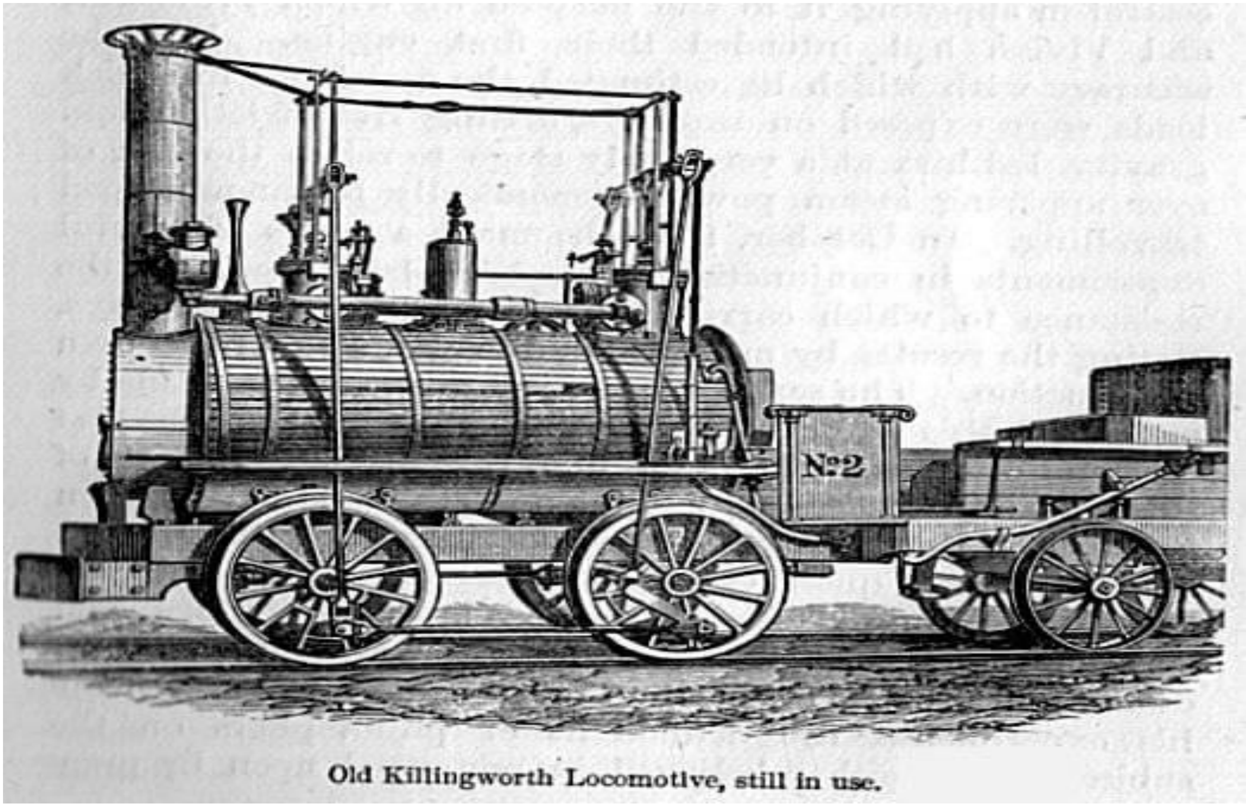


Figure 4.1 First Steam Locomotive Examples

5. DEFINITIONS OF RAIL SYSTEM VEHICLES

We can define rail system vehicles in general as follows.

Towing Vehicles: It is a vehicle that performs the function of pulling or pushing in accordance with its purpose with a mechanical force applied to its wheels.

Towing Vehicles: Vehicles intended to carry cargo or passengers in accordance with their purpose, which move by being pulled or pushed by a towing vehicle (Wagon or Trailer or Trailer)

Locomotive : It is a Rail System vehicle that moves with a mechanical power applied to its wheels and moves the towed vehicles connected behind or in front of it with this movement.

Automotrices (Motorized Wagon): It is a Rail System vehicle that moves on its own with a mechanical power applied to its wheels and performs the transportation function at the same time.

Train: A combination of Rail System vehicles consisting of one or more towed vehicles and towed vehicles or one or more towed vehicles.

Train Sets An inseparable combination of vehicles made up of automotrices/automotrices (motor cars/motorized wagons) and wagons of the same design (Trailer or Trailer).

Trams: Rail system vehicles for urban passenger transportation with low passenger carrying capacity, operating together with road vehicles in mixed traffic patterns.

Light Rail System: A train set with medium passenger carrying capacity, operating on lines allocated for urban passenger transportation, underground or above ground.

Metro: A train set with a high passenger carrying capacity that operates on dedicated lines underground or above ground for the transportation of passengers within the city.

Suburban A train set with a high passenger carrying capacity that uses the railway line to transport passengers within the city and to distant distances from the city centers.

6. TRAINS

Since we call the system consisting of towed and towed vehicles in rail systems a train, trains are classified according to their transportation purposes. If the purpose is to carry passengers, they are defined as passenger trains, and if the purpose is to carry freight, they are defined as freight trains. There are also trains that carry both passengers and freight, and these are called "mixed trains".

6.1 PASSENGER TRAINS

Passenger trains on railways are classified as follows.

Suburban trains,

Mainline passenger trains,

Short distance Mainline passenger trains, (Regional trains = Regional Train)

Long distance Mainline passenger trains, (Intercity trains = Intercity Train)

International Mainline passenger trains (International Train)

Mainline passenger trains can be classified according to their speed as follows.

- Mail trains, (Slow Passenger Trains = Omnibus Train)
- Express trains, (Express Train)
- High speed trains. (High Speed Train)

Passenger trains are composed of the following combinations.

Passenger trains made with a combination of locomotives and passenger wagons, Passenger trains with automotrices (motorized wagons),

They are passenger trains made with the combination of automotrices and wagons designed in accordance with the automotrices and made with the series we call train sets (train series).

Figure 6.1 A Passenger Train

6.2 FREIGHT TRAINS

As the name implies, freight trains are composed of different types of freight wagons for the transportation of different types of cargo in parallel with the requirements. Freight trains are in line with requirements;

Covered wagons,

Open wagons,

Ore wagons

Grain wagons

Coal wagons,

Cistern wagons,

Platform wagons,

Wagons for the transportation of cement,

Wagons carrying automobiles,

They are formed from wagons, such as special wagons, and are pulled by locomotive(s).

Trains composed of the same type of wagons and carrying the same type of cargo are called "Block Train", trains composed of different types of wagons and carrying different types of cargo are called "Mixed Load Train".

If the load to be hauled cannot be hauled by a single locomotive, additional locomotives are used. Additional locomotives are given in front, behind or in between according to the height of the slope (ramp) of the railway route and the tensile strength of the harness . These locomotives are called Support or Ranfor Locomotives.

6.3 KARMA TRAINS

In regions where there is not much passenger transportation, the number of passenger wagons used is small. In such cases, freight wagons are added behind the passenger wagons in order to maximize the traction capacity of the locomotive. Trains formed in this way are called "Mixed Trains".

6.4 OTHER TRAINS

In addition to the trains listed above, trains for road construction and repair are called Work Trains. Trains that are put into service in order to open the railway to traffic in a short time due to derailment (derailment of railway vehicles), carambol (collision of two trains), flood and natural disasters are called Emergency Trains.

7. TRACTING VEHICLES

There are two types of towing vehicles to be used according to train types.

Locomotives

Motorized Wagons (Automotrices)

7.1 LOCOMOTIVES

Locomotives are manufactured and used for different purposes. Their differences are limited to their speed, power and weight, but they fall within the same definitions in terms of energy types and power transmission scheme.

It is possible to define locomotives according to their intended use as follows

Passenger Train Locomotives,

Universal Locomotives,

Freight Train Locomotives,

Short Distance Road and Maneuvering Locomotives,

Maneuver Locomotives.

If the diesel locomotives to be used in passenger trains are to provide electrical energy to the passenger wagons behind them, they must meet this power from the traction power, which causes a reduction in traction power. Therefore, it can be applied to passenger trains that do not have a large number of wagons. If the number of wagons in the passenger train is high and the train will be pulled by a diesel locomotive, then a diesel electrogen group wagon is connected behind the locomotive to provide electrical energy to the wagons. This wagon is called Generator Wagon.

Although it is still in the past, if steam heating is to be applied to passenger trains supplied by diesel locomotives, "Steam Generator" and water tank are added to the diesel locomotives to be used for this purpose. In the old years, when only steam heating was done in passenger wagons, a steam generating wagon was connected to the rear of the locomotive. This wagon is called 'Sofaj Wagon'.

7.1.1 PASSENGER TRAIN LOCOMOTIVES

In passenger trains, train weights are not high, speed plays a primary role in these trains and their power is selected high to reach high speeds. The selected speeds are maximum 200 km/h according to today's railway standards. The passenger wagons to be connected to the rear of these trains are also designed for these speeds. Passenger trains in today's modern railway standards,

Conventional Passenger Trains,

It is defined as High Speed Passenger Trains.

Conventional passenger trains (Conventional - Conventional) are defined as passenger trains up to 200 km/h, while trains above 200 km/h are classified as High Speed Trains.

The first high speed trains produced in the world were produced as train sets. There is a locomotive with a driver's cab at both ends of the set, so there is no need to maneuver at stations. However, in the latest train sets, automotives are used instead of locomotives at both ends. In this way, more passenger capacity is provided in train sets.

In relation to our topic, it is also useful to know the world's high-speed trains. These are according to their initial and final speed;

Japan : Shinkansen 210 km/h, 270 km/h, 310 km/h

France : TGV (Train Grand Vitesse) 235 km/h, 270 km/h, 300 km/h

Germany : ICE (Intercity Express) 250 km/h, 280 km/h, 300 km/h

Italy : Pandolino (Tilt body train = Active Tilting) 270 km/h, 300 km/h

Spain : TALGO (Tilt body train = Passive Tilting) 220 km/h

Spain : AVE 250 km/h

England - France : Eurostar 300 km/h

Korea : 300 km/h

Turkey : High Speed Train 250 km/h

Passenger train locomotives can be diesel or electric. However, high speed train sets are electric, as it is not possible to reach high speeds with diesel locomotives.

Figure 7.1 Siemens Velaro D Series High Speed Train used in Turkey

7.1.2 UNIVERSAL LOCOMOTIVES

Universal locomotives are used for hauling both freight trains and passenger trains, mostly on freight railways. Their weights are kept as high as the axle load of the line permits for hauling heavy loads and their maximum speed is chosen around 120 - 140 km/h.

7.1.3 FREIGHT TRAIN LOCOMOTIVES

Speed plays a secondary role in freight trains. In this respect, they are manufactured as heavy as the axle load of the line allows in order to pull heavy loads. Since they are mostly intended to haul cargo, speed is of secondary importance. Their maximum speed is selected as 70 - 90 km/h.

7.1.4 SHORT DISTANCE ROAD AND SHUNTING LOCOMOTIVES

These locomotives are used for the following purposes.

- They maneuver heavy freight trains.
- They pull passenger trains that run short distances but are not heavy.
- They are used for transporting heavy freight wagons to and from stations close to large stations or on branch lines.

7.1.5 SHUNTING LOCOMOTIVES

They are also used in the shunting services required for the preparation of passenger and freight trains at large stations and for passenger trains running short distances but not heavy. They are used for maneuvering at stations, according to train weights;

Light Duty Shunting Locomotives: They are used in maneuvering services at stations where train weights are not high. Their power varies between 200 - 450 BG engine power (BG = Horsepower).

Medium Duty Shunting Locomotives: They are used for maneuvering services at stations where heavier trains are made. Their power varies between 450 - 650 BG engine power.

Heavy Duty Shunting Locomotives: These locomotives, apart from maneuvering services, are also used for taking and delivering freight wagons to the railway lines of other organizations which are close to the station and which we call as the transmission line. Their power is between 900 BG - 1100 BG engine power. Short distance road and shunting locomotives are included in this class.

Shunting locomotives are generally diesel-powered.

8. **CLASSIFICATION OF TOWING VEHICLES**

Traction vehicles in rail systems can be classified in different types. These classifications are valid for all Railways and Urban Rail System vehicles, in general;

By energy types,

According to power transmission schemes,

It can be made according to wheel arrangements.

Vehicles operating in both railways and urban rail systems are not very different from each other in terms of system, but they may show some minor differences.

8.1 CLASSIFICATION ACCORDING TO ENERGY TYPES

Energy is defined as the ability to do work. This ability provides a power and this power provides a force. In order for a towing vehicle to be able to pull/push both itself and the wagons (Trailer = Romork) behind or in front of it, it is realized by creating a force between its wheels and the rails depending on Adherence (Adhesion). In rail system vehicles, this force is provided by different types of energy, and since the birth of rail system vehicles, the following types of energy have been used and are still used according to technological developments.

a) Locomotives powered by steam energy,

b) Towing vehicles powered by diesel energy,

c) Towing vehicles powered by electric energy.

Although railroads have traction vehicles powered by these three types of energy, 'traction vehicles powered only by electric energy' are used in urban rail systems.

8.1.1 STEAM-POWERED LOCOMOTIVES

The first rail system traction vehicle is Steam Locomotives. It is based on the principle that pressurized steam energy moves a piston and the linear motion of the piston is converted into rotational motion in the wheels by means of connecting rods.

Steam energy is provided by liquid or solid fuels bringing water to a certain temperature and pressure. Hard coal, lignite coal, peat are used as solid fuels and wood was also used in the past. Crude oil or thick fuel-oil is used as fuel oil. Since the water and fuel used to produce steam energy must also be carried with them, they carry a separate wagon behind them for these. This wagon is called "Tender". In small power steam locomotives, there is no tender and the water tank and fuel tank are connected to the front of the locomotive.

Steam operation has brought with it many difficulties such as the difficulty of maintenance, the use of excessive maintenance personnel and driver personnel, the transportation of solid fuel from coal mines to the places of use and fuel oil from oil refineries, and the installation of water facilities at certain points for water supply.

High-powered steam locomotives operating on the main line carry their fuel and water in a wagon called a tender. Therefore, as a result of the depletion of the fuel, not only their working tracks (distances) are low, but also their efficiency is low at around 13% - 14%, which brings along an expensive operation.

The low number of tracks also requires the use of more locomotives, more locomotive driver personnel and more maintenance personnel. In this respect, steam locomotives are not suitable for today's economic conditions. However, they are still in existence in countries with very rich coal deposits, as well as being used in nostalgic touristic trains in many countries such as our country.

Figure 8.1 A Steam Locomotive

8.1.2 DIESEL-POWERED LOCOMOTIVES

Diesel traction vehicles are manufactured as both locomotives and motorized wagons (automotrices) according to the requirements. Diesel fuel (diesel) is used as energy. The name of the engines used is already Diesel Engine. Diesel Engine is an internal combustion engine and the Diesel Engines used have different constructive structures according to the characteristics of the vehicles.

If the towing vehicle is a diesel locomotive; the engine/motors are in-line engine or "V" engine and mounted on the chassis. If the towing vehicle is a diesel automotrix (diesel engine wagon), the engine(s) are tilted engines and mounted under the chassis. This not only provides more seating but also ensures that passengers are not disturbed by engine noise. However, in high-powered diesel train sets, above-ground engines are used.

The diesel fuel used in diesel tractor vehicles is transported from oil refineries to the place of use by fuel cisterns. Although this is a disadvantage of diesel traction vehicles, the weight of fuel transported is much lower than that of steam traction vehicles, so transportation costs are also low. Again, the advantages of oil pipelines further reduce transportation costs. Their efficiency is around 70% - 75% depending on whether they are diesel hydraulic or diesel electric. This efficiency is the efficiency between the diesel engine and the wheels, and if the thermal efficiency of the diesel engine is taken into account, the actual efficiency is around 35% - 45%.

Among the diesel traction vehicles, especially diesel locomotives have a great economic advantage over steam locomotives since their traction power is higher than steam locomotives and their working tracks are longer, requiring fewer locomotives to carry out the same transportation and consequently less maintenance personnel and less driving personnel.

Diesel tractor-trailers still dominate in countries with abundant oil deposits and reserves. However, it is an expensive operation for countries with poor or no oil reserves. Nevertheless, it maintains its advantage in line sections with low traffic density.

Diesel mainline locomotives are generally produced with a single driver's cab. In addition to diesel locomotives with a single driver's cab, diesel locomotives with a driver's cab on both sides as well as diesel locomotives with a cab in the middle are also produced.

Diesel tractor vehicles are also produced as autotmotris (motorized wagons).

Figure 8.2 A Diesel Electric Locomotive Type DE 22000

8.1.3 LOCOMOTIVES POWERED BY ELECTRIC ENERGY

Electric traction vehicles are produced as both locomotives and motorized wagons according to requirements. As the name suggests, they are powered by electric energy. There is no problem of storing and transporting the energy of these vehicles, and the electrical energy is readily available along the railway line.

Trams, Light Rail vehicles and Metro vehicles operating in the city motorized wagons and motorized wagons of suburban trains and electric train sets (including high-speed train sets) on railway lines with electrification are electrified. are produced.

The electrical energy used in electric traction vehicles uses different current types and values according to the areas of use and operating conditions. These are;

Direct current systems (DC)

They are alternating current (AC) systems,

While there are differences in values between systems, countries choose their values because of working conditions or obligations. Let us now write down these values.

Direct current systems (DC)

1000 Volt, 1500 Volt, 3000 Volt on railways

In urban rail systems: 660 Volts, 750 Volts, 1000 Volts, 1500 Volts

Alternating current systems (AC)

In railways, high value voltages are used to ensure that voltage drops and power losses are low. These values are

15000 Volts (15 kV) 16x2/3 Hz (frequency unit)

25000 Volts (25 kV) 50 Hz

20000 Volts (20 kV) 60 Hz)

In our country, 25 kVAC (25000 VAC) and 50 Hz electrical energy system is used in railways.

Warning: The type of current used in urban rail systems is Direct Current (DC).

In the railways of some countries, on lines with high traffic density, the electric system has been recognized as the most economical system. Advantages over other systems;

Low energy costs due to high efficiency (around 80%),

Low maintenance and repair costs and labor costs,

Their ability to reach very high speeds.

High traction capabilities because high forces can be applied to them, resulting in fewer vehicles, fewer drivers and fewer maintenance personnel,

It has many advantages such as providing comfort by providing electric energy to the wagons in passenger trains,

Although high initial facility costs are a disadvantage, they provide superiority over other systems in terms of low operating costs and meeting investment costs in a short time.

Figure 8.3 An Electric Locomotive Type E 68000

We have emphasized that the Urban Rail System vehicles are also electric-powered vehicles. These are;

Tram

Light Rail System

Metro

classified as.

Figure 8.4 An Electric Multiple Unit of Type E 23000

8.2 CLASSIFICATION BY POWERTRAIN

The wheel power required for the traction function is provided by a number of components from power sources. The problem is the transfer of power to the wheels. This transfer is provided by different devices in steam, diesel and electric systems according to the characteristics of the system. Apart from the steam system, the last elements that transmit power to the wheels in electric and diesel systems are necessarily a group of gear wheels. We have already mentioned that a power source is required for a towing vehicle to fulfill its towing function. This power source, according to energy systems;

In steam locomotives, steam boiler + water and fuel tank,

Diesel engine + diesel fuel tank in diesel towing vehicles,

In the case of electric towing vehicles, it is the power line that runs along the line.

In towing vehicles, power transmission to the wheels is realized by one of the following systems.

- Mechanical power transmission in steam locomotives,

- Vehicles towing diesel

a) Mechanical powertrain,

b) Hydraulic power transmission,

c) Electric powertrain,

- Electric powertrain in electric towing vehicles.

The powertrain of diesel electric towing vehicles and electric towing vehicles is, understandably, electric. In this respect, their powertrains are similar. The difference is that in the electric system the power source is the electric power line running along the line, whereas in diesel electric towing vehicles the electric energy is generated by the vehicle itself through the diesel engine and the electric generator.

According to the types of power transmission schemes and energy written above, traction vehicles are referred to as follows.

Steam locomotives,

Vehicles towing diesel,

Diesel Mechanical traction vehicles (DM) : Diesel Mechanical Locomotives and Diesel Mechanical Automotives

Diesel Hydraulic traction vehicles (DH) : Diesel Hydraulic locomotives and Diesel Hydraulic automotives

Diesel electric traction vehicles (DE) : Diesel Electric locomotives and Diesel Electric automotrices

c) Electric traction vehicles (E): Electric locomotives and Electric automotives.

8.3 CLASSIFICATION ACCORDING TO WHEEL ARRANGEMENTS

A rail system vehicle, whether it is a towed or towed vehicle, can only move on the rails with the wheels underneath and suitable for the profile of the rail.

The wheels are tightly fitted on both sides of a cylindrical shaft called an axle or axle and rotate with the same number of revolutions. A system consisting of an axle and two wheels is called a wheel set. Wheel sets;

Carriage wheels, (porter wheels = porter wheels)

Motric wheels are divided into two types (Motorized wheels = Driven wheels).

Carriage wheelsets are used on wagons, but they can also be used on locomotives and automotrices (motorized wagons) as required by the system, depending on the towing vehicle systems.

Motric wheels are the wheels that perform the towing function, and these wheels, whether diesel mechanical, diesel hydraulic, diesel hydraulic, diesel electric or electric towing vehicle, have a gear called a traction gear (axle gear). This means that the final power transmission element in traction vehicles is a gear connected to the axle. Driven wheels are also called motric wheels ir.

Wheel arrangements on towing vehicles are defined according to a number of rules. One of these rules is the number of wheels seen from the side.

8.3.1 DEFINITION OF TOWING VEHICLES MOVING ON WHEELS

Steam locomotives, small-powered diesel mechanical and diesel hydraulic shunting locomotives, small-powered diesel hydraulic automotives move on two or more sets of wheels and are defined as axle vehicles. Axle systems are not suitable for very high speeds.

In axle systems, power is applied to one wheel and if there is more than one driven wheel, the power is transferred from the main driven wheel to the other wheels by connecting rods or cardan shafts. The main driven wheel to which power is applied is called the "Motris Wheel" and the other driven wheels that receive power (rotational motion) from the motris wheel are called "Coupled" wheels.

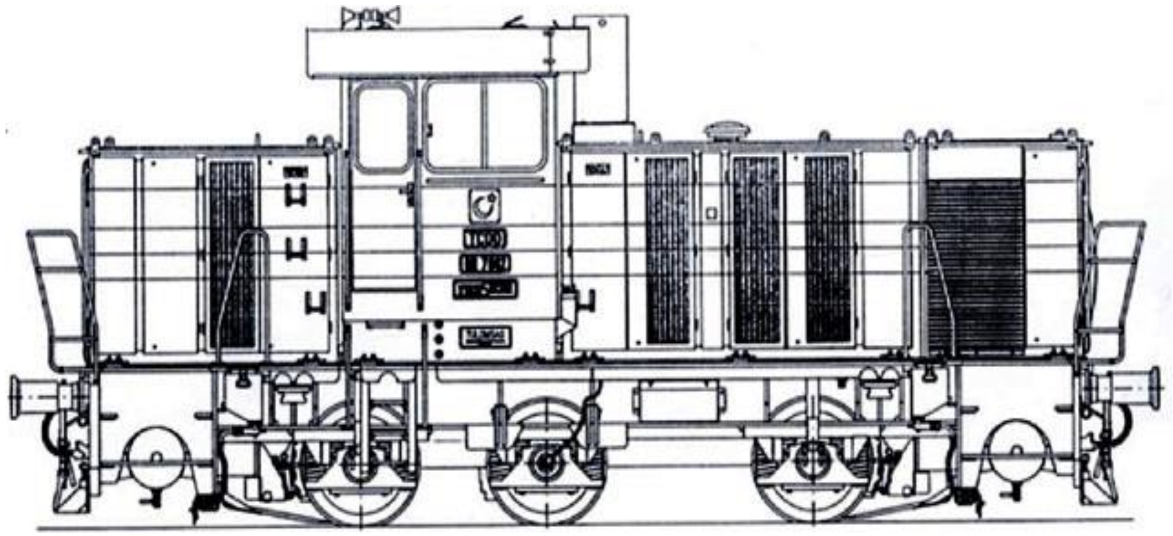


Figure 8.5 A 3 Axle DH 7000 Type Locomotive

8.3.2 DEFINITION OF WHEEL ARRANGEMENTS IN BOGIE TOWING VEHICLES

Bogies can be defined as walking sets or simply trolleys with more than one axle that carry the vehicle. Bogies are applied to mainline, diesel hydraulic, diesel electric, diesel electric, electric locomotives and automotives, shunting locomotives and urban rail vehicles.

Although axle systems do not have the ability to make high speeds, it is an advantage that bogie systems are suitable for high speeds and adapt more easily to the ribs. Bogies ;

Bogies performing the traction function (motorized bogies = driven bogies)

They are divided into bogies that perform the transportation function (porter bogies = porter bogies).

Bogies are also adapted to freight and passenger wagons, but since wagons perform only the transportation function, the bogies used in them are bogies that perform only the transportation function. Whether motorized (driven) or carrier bogies, a bogie has at least two axles (two sets of wheels) and at most three axles (three sets of wheels).

UIC's rules also apply in the definition of bogie systems. Again, letters identify the axles (wheel sets) that perform the traction function and numbers identify the axles (wheel sets) that perform the transportation function.

The letter order of the alphabet indicates the number of axles in a bogie (e.g. B = 2 and C = 3)

It means there are as many bogies as there are letters.

If there is a (') above the letter, it means that the bogie with bogie drive and the axles on the bogie are powered by a single engine.

If there is an (o) besides the (') above the letter, it means that each axle is powered by a separate engine.

If there is a number instead of a letter, the bogie is a non-driven bogie and the number indicates the number of axles.

For example; B' 2 , 1A'o A'o1 , C' C' , B'o B'o , B'o 2 , B'o B'o B'o B'o , C'O C'O , ... etc

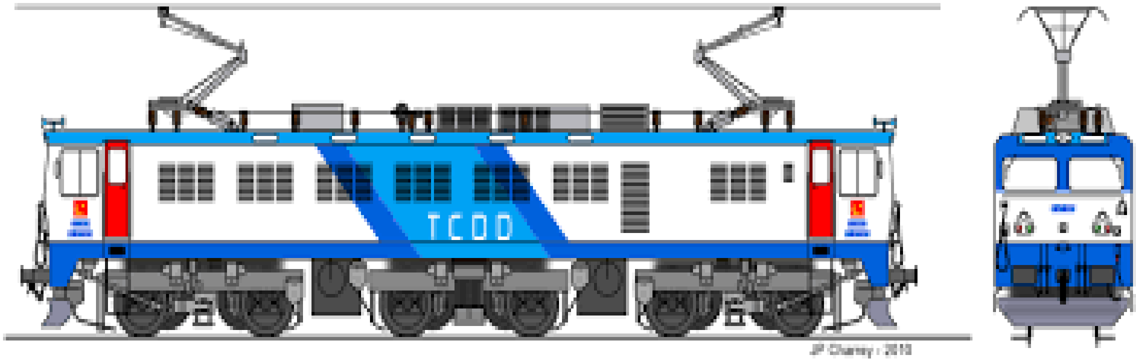


Figure 8.6 An E 43000 Locomotive with BoBoBo Bogie arrangement

9. COMMON STRUCTURE OF RAIL VEHICLES

Although towing and towed vehicles vary according to the type of service, they have a common structure in many aspects. This common structure,

Walking gear (wheelsets)

Main carrier (chassis)

Chest (fairing = protective)

(The chassis and crate together are defined as the vehicle body).

Towing vehicles are not very complex as they only fulfill the transportation function. On the other hand, towing vehicles have a more complex structure since they also fulfill the towing function. These features of towing vehicles cause the vehicle to be heavier than towed vehicles, that is, the axle load is higher. The biggest difference between locomotives and automotives (motorized wagons) is that automotives are more like passenger wagons.

9.1 COMMON FEATURES ACCORDING TO MARCHING TEAMS

Undercarriages not only carry the entire load of the rail system vehicles but also provide their movement. In towing vehicles, according to the wheel arrangement, there are also walking sets that perform only the transport function as well as the towing function. In towed vehicles (wagons), the running gear performs only the transportation function.

They can be undercarriage, axle or bogie systems. However, the rapid development of rail technologies has brought high speeds to these vehicles. When the limited speeds of axle systems and the increasing desire of people to travel comfortably overlap, especially the production of passenger vehicles has also shifted from axle systems to bogie systems. In this respect, only bogie systems will be emphasized.

9.1.1 BOGIES (BOGIE)

Bogies, in the simplest definition, were defined as trolleys that move on rails with the help of the wheels underneath and carry the entire load of the rail system vehicles. A bogie has a minimum of two axles (two sets of wheels) and a maximum of three axles (three sets of wheels), while a towing vehicle has a minimum of two bogies and a maximum of three bogies and the total number of axles does not exceed six. Towing vehicles have two bogies with a maximum of two axles.

The bogies used in light locomotives, i.e. passenger train locomotives and automotric (motorized wagons) and wagons, urban rail system vehicles, suburban train sets and high-speed trains are two-axle (B) bogies and the number of bogies is two (B B B) in each vehicle.

All axles of towing vehicles can have bogies (motorized bogies) that perform the traction function as well as bogies that perform the carrier function.

Heavy locomotives have two bogies with three axles or three bogies with two axles.

The traction bogies of a towing vehicle are identical and can be used interchangeably.

The traction bogies (motorized bogies) and carrier bogies of automotrices are skeletally identical.

Bogies are under the influence of the following forces and are designed to resist these forces.

When the vehicle is stationary, the vertical forces due to the weight of the vehicle only,

Additional vertical dynamic forces from the road when the vehicle is in motion, (Radial forces)

Lateral (axial) forces created by centrifugal force on curves,

Axial forces due to roll during take-off and braking and power changes, (Roll = Jerk)

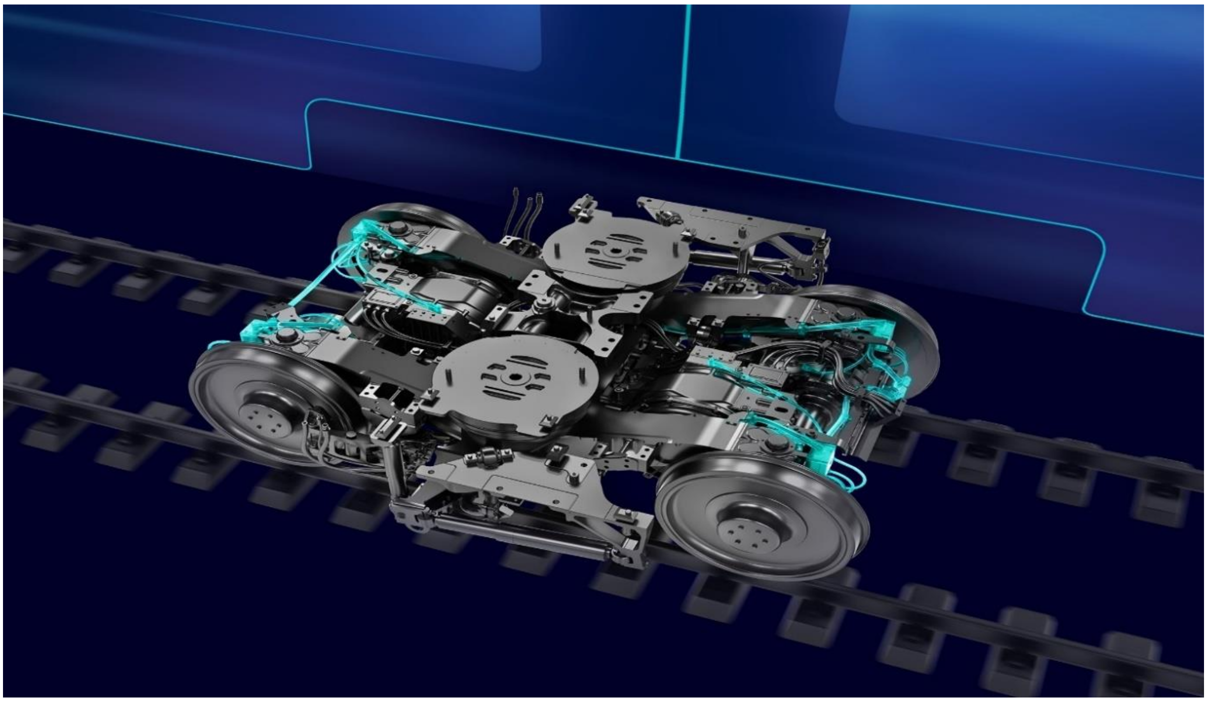


Figure 9.1 A Y32 Type Bogie

Bogies are manufactured as cast steel or box beam sheet construction. However, due to the difficulty in the production of cast bogies and the development of welding technology, bogies are nowadays produced with sheet metal construction.

In addition to performing the function of lifting and carrying the load of the vehicles, the bogies also carry the following parts.

They carry the dampers (suspensions) necessary to prevent the dynamic forces acting on the wheels of a moving vehicle from being transmitted to the bogie chassis. (Primary dampers = Primary suspensions)

They carry the necessary dampers (suspensions) to absorb forces coming from different directions and not transmit them to the chassis (prime mover) on which it is carried. (Secondary dampers = Secondary suspensions)

In the power transmission systems of diesel hydraulic and diesel mechanical vehicles, they carry the axle shifters, and in the electric power transmission systems, they carry the traction motors and gearboxes.

They carry the brake equipment necessary for stopping and slowing down vehicles.

They carry the nozzles (Nozzle) of the sand to be sprayed to increase the adherence between the wheel boden (wheel flange) lubricator and the wheel/rail used to minimize wheel/rail wear.

They carry the magnets and antennas of automatic train stopping (ATS) and automatic train operating (ATO) systems in modern rail vehicles.

Steel brushes, called Stone Shears, which will throw out the dangerous materials that may be placed on the rail, are also connected to the bogie.

Bogies are very important and the most difficult component to design in both towing and towed vehicles. A well designed and manufactured bogie minimizes wheel/rail wear and prevents rail corrugation. Especially for narrow gauge lines, "Self Steering" bogies have been developed and used successfully.

9.2 COMMON CHARACTERISTICS BY PRIME MOVER

The prime mover (Chassis) is a platform that sits on the bogies of towed and towed vehicles and performs a transportation task, and in general, there are no major differences between towed and towed vehicles.

The main role of the chassis in towing vehicles, in addition to carrying the main and auxiliary components, varies according to the services performed by the towing vehicles. These changes are as follows.

In traction vehicles that serve only as locomotives, they carry the main and auxiliary components necessary for the locomotive to perform its traction function.

In automotrices (motorized wagons), in addition to carrying the main and auxiliary components required for the towing function, they also serve as a base for the seating and standing places required for passengers. In this type of vehicle, the main and auxiliary components are usually placed under the prime mover so that passengers are not disturbed by noise and more seating and standing passengers can be carried.

In towing vehicles, equipment such as piping, electrical power cables, electrical control cables related to brake and air equipment are laid either under and/or on top of the prime mover, as the case may be.

According to the energy types, powertrains, axle arrangements and braking systems of towing vehicles, the prime mover carries the following equipment.

- In diesel-electric towing vehicles;

Diesel engine/generator group,

Compressor(s),

Traction motor cooling fans, (if available)

Electrical/Electronic equipment,

Engine cooling radiators,

Accumulator battery and charging equipment

Air tanks used for brakes and other tools,

Brake equipment,

Other equipment related to the functioning of the system.

- Electric towing vehicles;

Transformers and transformer cooling groups, (in alternating current systems)

Compressor(s),

Electrical/Electronic equipment,

Traction motor cooling fans, (if available)

Accumulator battery and charging equipment,

Air tanks used for braking and other purposes,

Brake equipment,

Other equipment related to the functioning of the system.

Due to the weight of the components mentioned above, the main carriers (chassis) are calculated to be resistant to deflection (bending). In order to compensate for the resulting deflection, some upward deflection is given during production. In addition, the weight of the components described above is distributed evenly on the prime mover to ensure a balanced adherence.

9.2.1 STRUCTURE OF THE PRIME MOVER (CHASSIS)

When towing and towed vehicles are stationary, the prime mover (chassis) is under the influence of static forces. These forces are vertical forces acting due to the weight of the components above or below the prime mover. The prime mover, which is supported on bogies on both sides, tries to bend (deflection) under the influence of these vertical forces.

In moving vehicles, in addition to vertical forces, vertical dynamic forces, horizontal and axial multi-directional forces are also manifested. The prime mover is designed to withstand these multidirectional forces and to avoid deformation in collisions up to a certain speed and severe buffer events in unintended accidents. For example, locomotive chassis are designed to withstand a compression force of 200 tons and tram chassis are designed to withstand a compression force of 60 tons. They are produced by welding construction of main carrier steel castings or profile steels.

9.2.2 BUMPERS

In the operation of both towed and towed vehicles, i.e. in the creation of a train system, a number of forces disturb the stability of the train system. Let us briefly examine what these negative forces are.

During maneuvers to form a train, forces parallel to the axis of the track act on the vehicle chassis when the vehicles are connected to each other.

In a moving train, at the moment of braking, different forces parallel to the rail axis occur between the vehicles due to different braking forces in the different types of towing and towed vehicles that make up the train.

When the train descends down ramps, the forces in the direction of descent due to the ramps result in compression forces of the vehicles against each other, again parallel to the track axis.

It is these forces that are negative;

In passenger trains, passengers are uncomfortable due to jolts, i.e. passenger comfort is impaired,

In freight trains; the loads in the wagons may slip, even the stability of the vehicle may deteriorate as a result of this slippage and cause derailment,

They cause equipment in towing or towed vehicles to malfunction due to vibration

The negative forces described above need to be eliminated partially or completely. However, it is not possible to completely eliminate these forces, but they are damped to reduce their effects. The elements that perform the damping process are called 'buffer'.

Figure 9.2 Buffers of DE 11000 Type Locomotive

Since the buffers of the vehicles in a moving train are in constant contact with each other, they are made convex in order not to create friction forces and to prevent wear. Again, the heights between the rail cork and the buffer centers should be within certain tolerances in order to prevent them from getting stuck to each other in motion. The International Railway Union (UIC) has introduced many limitations in this regard.

9.2.3 TOWING ARRANGEMENT

In order to be able to pull the towed vehicle behind the towing vehicles or the towed vehicles behind each other, a towing device is required. This device is connected to the prime mover (chassis) in the middle of both sides of the towing and towed vehicles.

Unlike bumpers, traction devices are elements that have elasticity against traction. The hooks that provide the connection are connected to an elastic package under the chassis and this package is called 'traction package'. Elasticity in this package is provided by conical coil springs or ring springs. In recent years, elostomer packages have started to be used.

The classical type towing harnesses used in railways are made in different towing capacities to take into account the operating conditions. These are known as 65 tons, 70 tons, 85 tons and 100 tons harnesses.

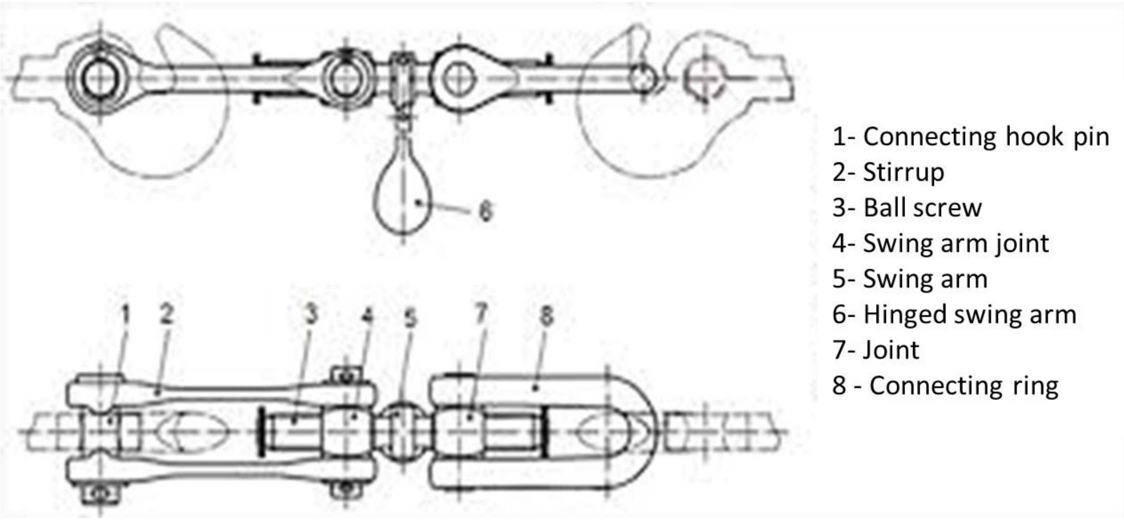


Figure 9.3 Hook Grip Harness

The most load on the harnesses comes on ramps. In this respect, high-value traction devices are used on railways with high ramps. For example; the high number of high ramp roads in Turkish Railways necessitated the use of 100 tons of towing equipment.

These harnesses are classical harnesses and semi-automatic pulling devices with higher pulling resistance (200 tons, 300 tons, etc.) are used especially for pulling heavy wagons. In semi-automatic harnesses, mechanical connections are made automatically and brake air connections are made manually. A feature of these harnesses is that they work against compression as well as pulling, i.e. they also act as a buffer. This type of traction harnesses are also called semi-automatic clutches.

Figure 9.4 Semi-Automatic Harness

In railways, in parallel with technological developments, semi-automatic and automatic traction devices (automatic clutches) are replacing conventional traction devices.

The clutches presented as semi-automatic clutches (harnesses) are applied in classical railways, more precisely in systems consisting of locomotives and wagons. They are designed for traction and compression only. The brake hoses are connected manually.

Fully automatic clutches (harnesses), on the other hand, automatically provide the necessary compressed air connections for pulling and pressing as well as electrical controls and brakes. This type of clutches are applied to the control wagons at both ends of the automotrices operating in MU (Multiple Unit = Multiple Operation) and at both ends of the train series. The connections between the wagons are provided by semi-fixed harnesses. In semi-fixed harnesses, mechanical connections, air connections and electrical connections are made manually to separate and connect the wagons.

Automatic harnesses and semi-fixed harnesses;

Commuter train sets,

A series of passenger train sets,

High-speed train sets,

Trams,

Light rail sets,

They are applied to metro sets.

Mechanical connections of semi-automatic harnesses and mechanical, electrical and pneumatic connections of fully automatic harnesses do not require a human. The harnesses are automatically locked when a stopped train train is hit by another train at a speed of 3-5 km/h. The disengagement operations can be done easily from the driver's cab with a single control or manually from below.

Figure 9.5 Fully automatic Harness

9.2.4 CRATE (BODYWORK)

In towing vehicles, the bodywork provides protection for the main and auxiliary components, as well as acting as a passenger carriage in motorized wagons (automotrices). In urban rail transportation systems, especially in low-platform trams, many electrical and electronic equipment is placed on the roof of the bodywork because there is no space under the chassis.

The driver, who is responsible for the control of towing vehicles, is located in the cab in the direction of travel and in front of the vehicle.

Bodyworks are made of different sheet materials depending on the characteristics of the vehicle. The body frame made of materials such as steel and stainless steel is connected to the main carrier. The closure is made of stainless steel or quality steel panels or aluminum alloy panels.

Since automotrices (motor cars) and train sets derived from automotrices are manufactured for passenger transportation, they are equipped with doors and windows on the sides. In locomotives, since the main and auxiliary components are located inside the bodywork, suitable ventilation windows are placed on the sides for their ventilation. Air filters are installed to prevent dust and water from entering through these windows. In locomotives, the section inside the bodywork where the components are placed is called the machine room.

9.2.5 DRIVER CONTROL CABIN

Driver's control cabins are designed in different ways, taking into account operating conditions and production costs. All traction, braking, heating, signaling and signaling systems of the towing vehicle managed by the driver, as well as the necessary safety indicators and control instruments and the train control and monitoring system are located in the driver's cab.

In locomotives used in railways, driver cabins are designed in three types.

Locomotives with driver's control cabin on one side,

b) Locomotives with driver's control cabin on both sides,

c) Locomotives with driver's control cabin in the center.

10. COMPONENTS USED IN TOWING VEHICLES

A towing vehicle manufacturer often does not produce all the components of the vehicle itself. They obtain many components from other companies specialized in this field. For example; diesel engine, wheels, compressor, air conditioning, etc.

In a tow truck;

Energy types,

Power transmission schemes,

Braking schemes,

Depending on the axle arrangements, very different components are required. Although different components are used for different systems, many common components are also used.

The components used in towing vehicles are as follows in order of their function and importance.

Power components and components (complements),

Common and similar components,

Auxiliary components,

Other components,

Indicators, light and sound warnings,

Systems to ensure safety of navigation,

Special systems.

Components work in an integrated manner with each other, regardless of their class in terms of function and importance.

10.1 POWER SUPPLY COMPONENTS AND COMPONENTS

In towing vehicles, the components that provide the power required to perform the towing function (traction function) can be defined as power components.

Power components are different in diesel and electric systems. In diesel systems, the component that provides power is the diesel engine/motors, while in electric systems, the components that provide power are the power supply stations that provide energy to the line. However, since a transformer is used in electrical systems with high alternating voltage, we can define this transformer as the power supply component.

10.2 ENGINES AND COMPONENTS USED IN DIESEL TRACTING VEHICLES

The power source used in diesel towing vehicles is the diesel engine(s) and the diesel fuel tank that provides energy to these engine(s). Diesel engines are internal combustion thermal machines and in towing vehicles, underground or above ground engines are used depending on the type of vehicles.

Underfloor diesel engines are applied to small-powered diesel automotrices (motor cars). Since these engines are under the ground, their height is not high and they can easily fit under the motris. These engines are also called tilting engines or boxer engines.

Diesel mainline locomotives and long-distance comfort trainsets (also called motor trains) derived from high-speed and diesel automotrices with high power requirements use above-ground diesel engines. These engines are located in the engine room on locomotives and in a compartment behind the driver's control cabin on automotric trains, which is designated as the engine room. Above-ground diesel engines are produced as row engines or 'V' engines.

Diesel locomotives used in railways operate in very different regimes according to the road and load conditions (ramp, kurb, etc.). Locomotive engines, which are faced with regime changes at any moment, must be robustly built engines (Robus engine). For this purpose, engines with low speed, but large cylinder dimensions and high number of cylinders are selected. In this case, the engine will be large in both size and weight.

Although the efficiency of diesel engines is around 36%-37%, in order to increase their efficiency, exhaust gas is utilized and overcharging is done with the help of turbo-compressors (Turbo charging). In this way, the efficiency of the engines is increased up to 45%.

Since diesel engines are internal combustion thermal machines, temperatures above a certain regime temperature are not allowed during operation. If temperatures above a certain regime temperature are exceeded; deformations occur in the engine pistons, cylinders and engine body due to high temperature, which causes engine damage. To prevent engine damage, engines are cooled with water. Cooling is achieved by circulating water through water channels in the engine casing and cooling the circulated water on an external circuit. This external cooling circuit is called the radiator circuit.

Depending on the weather conditions, it may not be necessary to pass the engine coolant through the radiators, as diesel engines will not overheat if they run at idle speed or at low power. In such cases, the coolant is circulated through a bypass pipe. For this purpose, a short circuit is provided with a thermostatic valve. Often, the temperature of the diesel engine coolant is also controlled by opening and closing louvers placed in front of the radiators and controlled by thermostats. In this way, the engine water temperature is controlled by providing communication with the outside air. Air is filtered to prevent dust and foreign substances in the air entering the radiators from entering between the radiator combs, preventing air circulation and preventing full cooling.

The hardness of the cooling water used in the diesel engine must be low. Otherwise, that is, if hard water is used, stones will form in the cooling water channels of the engine, causing the cross-sections of the water channels to shrink and cooling will not be sufficient. For this reason, Zeolitic Water is used to reduce the hardness of the cooling water used in diesel traction vehicles. Zeolitic water is supplied from Zeolitic water plants installed in Diesel Maintenance Depots.

Fuel is supplied by the fuel tank. Since the fuel tank is under the vehicle, a fuel pump is used to send the fuel to the engine. This pump is called a refueling pump and the engine that drives this pump is called a refueling engine. Since each different power of the diesel engine requires a different amount of fuel flow rate, the refueling pump sends the amount of fuel required by this power to the engine.

As in all types of explosion engines, diesel engines also have a lubrication system to minimize wear on the friction surfaces and to prevent heating due to this friction. The oil circulating in the lubrication system is passed through oil filters to prevent very small metal particles from mixing with the oil due to friction. Again, there are oil cooling circuits to prevent the heating of the heated oil. The oil in the crankcase of the diesel engine is subjected to certain tests. These tests are flammability and viscosity (fluidity) tests, which are the tests performed at every service return of the vehicle, and sediment and metal tests performed at certain periods. Oil filters are also changed at certain intervals.

10.2.1 ELECTRIC GENERATORS IN DIESEL TRACTION VEHICLES

In diesel-electric traction vehicles, the power source is the diesel engine, but both the power transmission system and the electric motors that power the wheels, which we call traction motors, then the mechanical power of the diesel engine must be converted into electrical power.

In the old years, the traction motors of diesel electric traction vehicles, especially diesel electric locomotives, were direct current collector traction motors, while the rotary electrical machine that feeds these motors and takes its motion from the diesel engine is called "Generator". The generator is a collector direct current generator. In this type of traction vehicles, besides generating electricity, the generator also acts as a starter motor that gives the first movement to start the locomotive. This system is called DC/DC system and since it is far behind today's technology, diesel-electric locomotives are no longer produced in this system.

With the development of electrical/electronic technology and the development of semiconductors, AC/DC systems and later AC/AC systems emerged. Here, the first letters show the shape of the electric current produced by the electric generator and the second letters show the shape of the electric current of the traction motors. In these systems, the electric generator powered by the diesel engine is called "Alternator" and produces three-phase alternating voltage. Alternators are classified as "Synchronous Machine".

10.3 TRANSFORMERS AND COMPONENTS USED IN ELECTRIC TOWING VEHICLES

In high voltage alternating current (AC) overhead line systems (Overhead line = catenary) in railways, it is not possible to directly apply the high alternating voltage received from the overhead line to the traction motors. For this purpose, the high voltage received from the overhead line is reduced to the values that are the operating voltage of the traction motors. Again, auxiliary components and circuits used in traction vehicles operate with low voltage. These low voltages are also provided by transformers.

Transformers are static electrical machines that convert high alternating voltage (AC) to low alternating voltage and vice versa, low voltage to high voltage. The input winding of transformers that change voltage with the electromagnetic properties of the windings wound on an iron core is called "primary" (first winding) and the output winding is called "secondary" winding (second winding).

The transformer of a towing vehicle supplied with alternating voltage has the following secondary windings according to the circuits to be fed.

Traction secondary winding(s),

Auxiliary circuit secondary windings,

Heating and air conditioning circuit secondary windings

High voltage alternating current systems are applied as single phase systems. The input side of the transformer is the overhead line side and the complementary side of the circuit is the rail circuit. One end of the heating and air conditioning secondary winding is connected to the rail circuit. Because the rotations of the electrical installations of the wagons pulled by electric traction vehicles are also provided from the rail.

The energy losses created by the electric current passing through the transformer windings and the magnetic losses occurring in the magnetic circuit manifest themselves in the form of heat, and the heat above a certain value causes the insulation of the windings to lose its properties and scorch. The resulting temperature is allowed to rise up to a certain limit, but higher temperatures are not allowed. Therefore, such power transformers must be cooled. The cooling process is carried out in specially obtained and insulated transformer oil.

In small power electric automotives (motor cars) the transformers are mounted under the chassis and the cooling of the oil in motion is carried out naturally by the effect of the wind, whereas in high power electric locomotives and automotives forced cooling is mandatory. Transformers, whether naturally cooled or forced cooled, are housed in an oil bath. In forced cooling systems, the oil is drawn from the upper part of the transformer by an oil circulation pump (Circulation - Circulation) and returned from the lower part of the transformer tub over the cooling radiators. If the oil passing through the radiators cannot be cooled sufficiently, the radiators are also cooled by a cooling fan.

Transformer windings are very sensitive to moisture. For this reason, the covers must be well sealed and care must be taken to prevent water and moisture from entering. In order to prevent moisture from destroying the insulation of the transformer oil, the circulated oil is passed through moisture traps (silica gel). Dirt and metal traps are also provided on the same path.

Transformer oils are tested in certain periods. These tests are acid test and dielectric tests. Acid corrodes the transformer windings and causes the insulation to deteriorate, and low dielectric value causes the permeability of the oil to decrease, causing electrical jumps and explosions of the windings. If the acid value is high and the dielectric value is low, the oil of the transformer is changed. In order to prevent the transformer oil from reaching the values written above, treatment (improvement) is performed in certain periods. Tretman is carried out with the help of a special machine. The transformer oil is circulated through this machine for a certain period of time and the dirt and metal powders are cleaned and the moisture in it is evaporated.

Since transformers are static electricity machines, their efficiency is high. Therefore, the efficiency of electric traction vehicles is higher than that of diesel traction vehicles.

10.4 COMMON AND SIMILAR COMPONENTS

There are many common or identical components used in both electric and diesel electric traction vehicles. For example, the traction motors of an electric traction vehicle and a diesel electric traction vehicle manufactured by the same company, and the power transmission components of an electric traction vehicle and a diesel electric traction vehicle manufactured by the same company may be identical, provided that they have the same power.

10.5 CER MOTORS

In electric traction vehicles and diesel-electric traction vehicles, traction motors are the last component to power the wheels with a gear group. Besides being the last component to power the wheels, traction motors also work as generators during dynamic braking. This means that every electric motor is also a machine that generates electricity.

The following traction motors have been used until today.

Alternating current (AC) motors with collector,

Direct current (DC) motors with collector,

Synchronous (AC) motors

Three-phase (three-phase) (AC) squirrel cage induction motors (induction motors)

Alternating current (AC) motors with collectors are outdated compared to today's technologies and are no longer preferred.

Synchronous motors were used for a period and are no longer preferred with the introduction of asynchronous motors.

The traction motors currently used are collector direct current motors and asynchronous motors, and direct current collector motors are no longer used in newly manufactured vehicles, and three-phase squirrel cage asynchronous motors are used instead as a result of the development of electrical/electronic technology.

10.5.1 COLLECTOR DIRECT CURRENT MOTORS

In addition to being used as motors, collector direct current motors are also used as electricity generators during Electro-Dynamic braking. Therefore, we can call them collector direct current machines.

Collector direct current machines basically consist of two main parts. These parts are

Stationary part (Inductor)

It is composed of a rotating part (armature) and according to the way the inductor and the inductor are connected to each other;

Series machines

Shunt machines

Compunt machines

They are divided into four as free excitation machines.

The inductor, which is the stationary part, constitutes the main poles of the motor and is connected to the body of the motor, which we call the carcass. As it is known, the inductor is the rotating part and consists of two parts. It is the collector (collector) consisting of a hair package and copper lamellae (collector), which forms the magnetic circuit on the same shaft and has the winding channels and windings on it. The windings are connected to the collector and the connection with the inductor windings is provided by coal brushes. In order to ensure a good connection, the coal brushes are pressed with switches. The elements that support the coal brushes are called coal carriers.

The most important feature of this machine is that it provides a large starting torque. Especially for vehicles operating on steep ramped roads, series engines provide great advantages.

10.5.2 ALTERNATING CURRENT SQUIRREL CAGE ASYNCHRONOUS TRACTION MOTORS

As a result of the development of semiconductor technologies and their high power levels, "Three Phase Squirrel Cage Asynchronous" traction motors (also called three phase induction motors) have been used instead of collector motors in both electric and diesel electric traction vehicles in recent years.

Induction motors are cheap machines in terms of both structure and ease of production and do not require much maintenance. These motors are of two types, single-phase and three-phase, and are also divided into two types as ring rotor and squirrel cage rotor. However, three-phase squirrel cage asynchronous motors are used as traction motors in rail system traction vehicles.

Asynchronous motors consist of the stator, which is the stationary part and the windings that provide the rotating field, and the rotor, which is the rotational part with fixed rods as a squirrel cage, as in every rotational electrical machine.

In alternating current (AC), each of the three phases is denoted by a letter and the letters of these phases are R-S-T. Each phase is 120° apart and a rotating field is generated in the stator windings. The resulting rotating field generates a torque in the rotor windings and hence a rotating force.

Asynchronous traction motor power transmission systems have significant advantages over collector direct current traction motors and these advantages are listed below.

Since there is no collector, there is no coal problem, i.e. coal consumption.

Maintenance costs are low as they are very easy to maintain.

As they provide a more linear traction force, a more uniform adherence is achieved.

Since they are easy to produce, production costs are low.

They have higher efficiency and therefore lower energy costs.

It is lighter than a collector engine of the same power.

10.5.3 USE OF TRACTION MOTORS IN BRAKING

Rail vehicles are operated according to certain traffic rules. According to these rules, vehicles must maintain a certain speed limit when stopping, slowing down or going down ramps. For this purpose, braking is applied to towed and towed vehicles.

In all rail system vehicles, braking is done with a brake system called friction brake. Friction braking is done with pneumatic (air) devices and in recent years, in urban rail system vehicles, it is also done with Hydro-Dynamic devices.

The essence of friction braking is to reduce or reset the kinetic energy carried by the train system by creating a force in the opposite direction by pressing on the vehicle wheels at a certain distance. Reducing kinetic energy means reducing the speed of the vehicle(s), and resetting means resetting the speed of the vehicle(s).

As it is known, every mass in motion has a kinetic energy depending on the value and speed of the mass. In order to utilize the kinetic energy depending on the mass and speed in moving rail systems and to provide a benefit in return, brake systems, which we generally call "Dynamic Brake", have been developed in towing vehicles. Thanks to this brake system, support is provided to the friction brake system and since the friction brakes will be used less thanks to this support, a significant economy is achieved in the consumption of brake pressure elements (sabo) and in the reduction of wheel wear.

In diesel-hydraulic traction vehicles, the dynamic brake is defined as "Hydro-Dynamic" brake, while in electric and diesel-electric traction vehicles, the dynamic brake is realized as an electric brake and is called "Electro-Dynamic" brake. In this system, the traction motors are operated as an electricity generator (generator) by utilizing the inert kinetic energy during braking and an electrical energy is obtained. This electrical energy is somehow spent and the kinetic energy is spent, which means a decrease in speed.

In electro-dynamic braking, the expenditure of kinetic energy is realized by two types of braking processes. These are;

Rheostatic brake,

It is performed in the form of regenerative braking.

In rheostatic brake application, the expenditure of electrical energy is provided by resistors. In other words, electrical energy is discharged on the resistors. In other words, it is discharged as heat energy. In electrical systems, electrical energy is given back to the supply line and if this energy is consumed by other electric vehicles on the line, this is called regenerative braking and economy is provided from electrical energy by giving back 15% to 25% energy depending on the ramp condition of the line.

Rheostatic braking is applied to both electric and diesel electric traction vehicles, while regenerative braking is only applied to electric traction vehicles. Generally, both rheostatic brake and regenerative brake are applied to electric traction vehicles. In modern rail vehicles, the vehicle first switches to regenerative braking. However, if there are no other vehicle(s) on the line to use electrical energy, then it automatically switches to the rheostatic brake position.

In electrodynamic braking, whether rheostatic or regenerative braking, traction motors operating as generators cannot generate electrical energy below a certain speed. Therefore, below a certain number of revolutions, the electro-dynamic braking effect disappears. After that, the friction brake is activated to stop the vehicle. In modern rail vehicles, after the electrodynamic brake loses its effect, the friction brake is automatically switched to the friction brake.

Warning: Regenerative braking is not applied on diesel electric vehicles.

11. COMMON AUXILIARY COMPONENTS USED IN TOWING VEHICLES

The ability of towing vehicles to perform their towing and braking functions flawlessly, as well as other services, is only possible with the support of many auxiliary components. Auxiliary components vary in towing vehicles, depending on the type of energy and power operating modes, but there are common auxiliary components that must be used in all types of towing vehicles.

11.1 AIR COMPRESSOR

It is known that a braking process is required to stop, slow down or maintain a certain speed limit on down ramps in order to stop, slow down or maintain a certain speed limit when the towing vehicles are in motion. Braking can be done with friction brakes or dynamic brakes or a combination of these two braking systems depending on the situation.

Friction braking is provided by a friction force applied in the opposite direction to the direction of rotation of the wheels. Although friction braking is provided by compressed air, in recent years, hydraulically controlled friction braking systems have been applied in urban rail vehicles. The friction braking force of friction brakes is provided either by pressing the wheel rolling circle or by pressing the disks connected to the axle.

The air required for the friction brake system working with air (pneumatic) pressure is supplied by a machine called a compressor. The compressor, which pressurizes the air it receives from the atmosphere by compressing it, fills this air into a tank. This tank is called the 'Main Air Tank'.

The compressed air obtained from the air compressor is not limited to the use of friction brakes, but is also used for the following purposes.

In electric towing vehicles, if the lowering/lifting of the current receiver called 'Pantograph', which receives electrical energy from the overhead line (catenary) and is called 'Pantograph', is carried out electro-pneumatically, it provides the operation of the air motor that performs the function of lowering and lifting the pantograph.

Again, in electric towing vehicles, if the automatic switch, which we call the "Main Circuit Breaker", is electro-pneumatically controlled, it provides the compressed air required for the activation and removal of this switch.

In towing vehicles, especially in rainy weather, it is necessary to spray sand on the rails to increase the adherence between the wheel/rail and thus prevent the wheels from skidding. Sandblasting is achieved by spraying sand from sand tanks located under the towing vehicle onto the rails with compressed air.

If the doors of electric and diesel automotric (motor cars) and train sets derived from them are opened and closed automatically and the automatic opening and closing process is provided by compressed air, it provides the compressed air for this work.

In some towing vehicles windshield wipers are operated by air motors. These motors provide the compressed air necessary for their operation.

It provides the necessary compressed air for warning horns on towing vehicles, especially locomotives.

Since it is known that a machine needs a power to do work, and since the compressor does work with rotational movement, it will need to receive a power. Compressor/compressors receive this power in different ways according to vehicle types.

In diesel hydraulic and diesel electric traction vehicles, from an electric motor driven by the movement of the diesel engine through cardan shafts or by electricity generated by an electric generator (generator) connected to the diesel engine,

Electric towing vehicles are powered by an electric motor.

Compressors take air from the atmosphere. According to the weather conditions, they do not discharge the air directly to the installation under conditions such as humid air, dusty air. Air filters are placed in the compressor air outlet circuit to keep the dust in the dusty air, and air dryers are placed in the compressor air outlet circuit to prevent the humid air from being pumped into the main tank.

11.2 BATTERY AND CHARGING CIRCUIT

The importance of the battery and the circuit that charges this battery is very important in towing vehicles. As it is known, Batteries (accumulators) are elements that chemically store direct current (DC) electrical energy and return it back as DC electrical energy when desired. According to the need, batteries are formed by serial and parallel connections with each other and are charged (Charging = Charging) with the help of a DC charging group. The electrical energy storage capacity of the batteries is defined as Ampere x Hour (Axh) and is charged according to this value (Charging = charging).

Filling process,

In diesel vehicles, a charging dynamo (charging dynamo = generator), powered by the diesel engine

In the case of electric towing vehicles,

(a) In direct current (DC) supply systems, the voltage of the system is reduced by different methods,

(b) In alternating current supply systems, the alternating voltage taken from the transformer auxiliary winding is rectified with a rectifier group.

In a towing vehicle, the battery provides the electrical energy for the following circuits.

All control circuits,

Interior and exterior lighting of vehicles, In diesel vehicles, the starter motor that gives the first movement to the diesel engine,

Opening/closing mechanisms of electrically controlled automatic opening and closing doors on electric and diesel train sets,

Protection and control circuits.

11.3 TRACTION MOTOR COOLERS

In both electric and diesel electric traction vehicles, the last component that transmits power to the wheels is the traction motors, and as in every electric machine, traction motors have two circuits, electric and magnetic circuits. Depending on the current in these circuits, losses that turn into heat occur. These losses are Hysteresis and Fuko (Foucault) losses (Iron losses) in the magnetic circuit and Jul (Joule) losses (Electric losses) in the electrical circuit.

The losses, which manifest themselves as heat, cause the insulation of the windings of the traction motors to burn and scorch, as well as the copper material that forms the windings. This heat also causes the sheet metal package that makes up the magnetic circuit to lose its properties.

The increase in temperature also causes an increase in the resistance of the windings, which leads to a decrease in the current flowing through them and therefore to a decrease in power. For this reason, traction motors are allowed to heat up to a certain degree. In order not to exceed this temperature, it is necessary to cool the traction motors.

In small power traction motors, cooling is provided by a cooling fan (propeller) connected to the shaft of the traction motor. This cooling system is called autoventilation (self-cooled). However, since autoventilation is insufficient at high powers, an additional cooling system is required and forced cooling is done by means of a separate Fan (Ventilator = Blöwer) from outside.

Traction engine cooling fans derive their motion from the rotational motion of the diesel engine or, in the case of diesel electric vehicles, from an electric motor supplied by an auxiliary circuit alternator or main alternator,

In electric traction vehicles, they are powered by DC or AC electric motors, depending on the supply system.

11.4 COOLING OF CURRENT EXCHANGER (CONVERTER) COMPONENTS

The current changers used in both traction circuits and auxiliary circuits, especially in diesel electric and electric traction vehicles, are made of semiconductors. Semiconductors, in order of development; Diodes, Thyristors, GTOs (Gate Turn Off) and IGBTs (Insulation Bipolar Gate Translation).

Since semiconductor elements are electrical elements, it is known that an electric current will pass through them and the passing electric current will release heat energy as in other electrical elements. Although the resulting heat energy is allowed to rise to a certain degree, higher temperatures cause the semiconductor elements to burn, that is, to be destroyed. It is therefore necessary to cool the semiconductor elements. In small power traction vehicles, this cooling process is carried out naturally, but in high power vehicles, forced cooling is required. Forced cooling process:

Air cooling,

Water cooling

It is made in the form of gas cooling.

11.5 AUXILIARY COMPONENTS USED IN ELECTRIC TOWING VEHICLES

In electric towing vehicles, a number of auxiliary components are required to support the main components that perform the towing and braking functions. The most important feature of these components is that they are equipped with electrical and mechanical locking systems in conjunction with each other.

11.5.1 CURRENT RECEIVERS

It is known that electric traction vehicles receive electrical energy from an electric power line following the railroad. Electric energy is taken from these lines by current receivers by friction.

Current receivers press the power lines with switches to ensure uninterrupted power, whether it is a third rail system or an overhead line system. All above-ground electric traction vehicles (trams, railroad electric traction vehicles) and some underground light rail and subway vehicles receive electrical energy from the overhead line with a current receiver called 'Pantograph'. Pantographs are made up of two parts called body and rigging.

The arc is the current receiving part and is perpendicular to the line axis and the electrical energy is received with the help of two copper-carbon mixture bands that constantly rub against the overhead line. They move on sustains so that the contact with the overhead line is not interrupted due to gaps from the road, i.e. vertical shocks. The width of the archeses is 1600 mm or 1950 mm depending on the tunnel gauge of the railways. In old railway lines, in case of electrification, 1600 mm wide arches are used because the tunnel gauges are low, while 1950 mm wide arches are used in newly constructed lines that are suitable for electrification gauges. Pantographs used in urban rail systems can have different values. The pantograph body is lifted/lowered by means of lifting springs with an electro-pneumatic or electric motor. The lifting springs can be adjusted considering the snow and ice load in winter. In towing vehicles, the pantograph body is supported on insulators on the roof. The height of the insulators varies according to the value of the tension.

In order to ensure that the coal belt is not taken from a continuous point but homogeneously across the width of the belt, the catenary contact wire is installed with right and left zigzags between the poles according to the line axis. These zigzags made according to the line axis are called 'Dezekszaman' and according to the gauge gauge of the pantograph, the dexzaman value is +/-35-40 cm according to the line axis.

The number of pantographs varies according to the power of the vehicle and the system. However, electric locomotives have one pantograph on each side. However, during operation, the rear pantograph is used according to the direction of travel, the front pantograph is dismounted. Although the pantographs on both sides are in the same gauge, in line sections with different gauge sizes, one pantograph is operated in one gauge and the other in the other gauge. (For example; one pantograph is 1600 mm, the other is 1950 mm)

Figure 11.1 Pantograph

11.5.2 RAIL RETURN CURRENT AND GROUNDING EQUIPMENT

In electrical systems, it is known that the return line is the rails, whether the current is taken from the pantograph or the third rail. The return from the vehicle electrical circuit to the rails is provided by the rail return equipment. This return current connection is realized with the help of coal brushes pressed by switches mounted on the axle heads.

Apart from the rail return device, the body of the vehicles is connected to the bogies with flexible organization copper cables. Because the EMC (Electro-motor-force) and static electric charges caused by the magnetic field occurring in the power transmission lines are transmitted to the rails with the help of these connections and discharged.

11.5.3 MAIN CIRCUIT BREAKER (FAST CIRCUIT BREAKER)

In electric traction vehicles, the electrical switch that allows the electrical energy received by the current receivers to be transmitted or interrupted to the main components is called 'Main Circuit Breaker' (Disjunctors). Main circuit breakers function under the following conditions.

For deactivating and activating the electric vehicle,

To protect the system by automatically cutting the circuit in case of overloads,

To protect the system by automatically cutting the circuit in case of short circuits in the system

Although they are usually placed on the roof of the vehicle, in modern electric towing vehicles, they are placed inside the towing vehicle (in the engine room) in order not to disturb the aero-dynamic structure and to prevent damage from external factors, as well as for ease of maintenance.

In main circuit breakers, very high electrical arcs occur during deactivation and activation. These arcs must be extinguished in a very short time as they cause the destruction (wear) of the contacts that provide the electrical connection. Extinguishing is done either by blowing compressed air or in vacuum. The on/off times are short on the order of ms (milliseconds) to avoid arc extensions. (For example: 0.045 seconds)

The main circuit breaker is a key component in electric towing vehicles. In order to prevent electrical faults that may occur in the main and auxiliary components of the vehicles from causing damage to the components, all electrical fault notifications are collected in the main circuit breaker and damages are prevented by opening the circuit.

11.5.4 GROUNDING SEXTON

In electric towing vehicles, high voltage circuits must be earthed for safety under certain operating conditions. For any reason, it may be necessary to remove a damaged component on the roof of an electric towing vehicle traveling on the line and take it down. For this, the following procedures must be performed.

The power line (overhead line) is de-energized.

For the discharge of static electricity occurring on the overhead line, the line and the rail are grounded. When this grounding is done, first the end of the grounding rod is connected to the rail (with a clamp suitable for the rail profile) and then the hook of the grounding rod is hung on the line.

The arm to activate the sectionalizer is taken and the earthing sectionalizer is activated.

Then go up to the roof.

If the above written operation is performed, even if another person wants to start the vehicle, the main circuit breaker in the main supply center cuts the circuit because the earthing sectional line is short-circuited.

11.5.5 PHASE CONVERTERS (CURRENT CONVERTERS)

In electric traction vehicles, the auxiliary circuit motors are supplied by direct current or alternating current traction motors, depending on the system. If the auxiliary circuit traction motors are collector motors, due to the difficulties arising from their maintenance, three-phase squirrel cage asynchronous motors are now used in today's electric traction vehicles. Phase converters are used to supply these motors. Phase converters in this system are components that convert single-phase alternating voltage to three-phase alternating voltage or direct voltage to three-phase alternating voltage by means of a converter group,

Rotary (dynamic) phase converters,

There are two types of static phase converters.

Dynamic phase converters are rotary type and are both noisy and difficult to maintain. In advanced electric traction vehicles, static phase converters are now being used instead of rotary converters.

The following circuits are fed from phase converters.

Compressor motor(s)

Traction motor cooler fan motors

Transformer recirculation pump motor and radiator cooling motor

Phase converters cooling circuit motors

Driver windshield wiper motors

Battery charging circuit

HVAC circuits in automotives and train sets.

Other engines required.

Static phase converters are no different from the converters used in three-phase asynchronous motor-driven power transmission systems used in diesel electric and electric traction vehicles. They still use GTO or IGBT semiconductors (in the past, tristors were used).

11.5.6 OTHER COMPONENTS

In towing vehicles, in addition to the main and auxiliary components required for towing and braking, a number of other components are used to support these components or for other purposes. Some of these components provide passenger comfort and safety as well as navigational safety and comfort.

11.5.6.1 WINDSHIELD WIPERS

Windshield wipers are used in rainy weather so that drivers can see clearly in front of them. These wipers are powered by a small electric motor or an air motor. In addition, an anti-fog device is installed on the windows to prevent fogging. This device can be electric or compressed air blown.

11.5.6.2 SANDBAGS

In rainy weather or on lubricated rails, sand is sprayed on the rails to prevent possible skidding incidents between the wheels of the towing vehicles and the rail and to increase the adherence. For this process, sand spray nozzles are placed on the wheels in the direction of travel on both sides of the towing vehicles. Whichever direction the vehicle is traveling, sand is sprayed onto the rails with the help of compressed air, manually controlled by the driver with a foot pedal or hand button. In modern vehicles, sandblasting takes place automatically as soon as the wheel goes into a skid

The sand to be used is specially prepared, dried to a certain grain size, sieved and sieved sand with low clay content and stored in sand tanks located under the bogie or chassis. The volumes of these tanks are determined according to the intended use of the vehicle and the operating time and conditions.

11.5.6.3 LIGHTING

Lighting in towing vehicles is divided into two as interior and exterior lighting. As exterior lighting, projectors are placed on both sides of the vehicles so that the driver can easily see in front of them at night and in the dark tunnel. Signaling and parking lights (green, red, white) are also placed on both sides of the vehicles on the right and left. In addition to exterior lighting, train number, vehicle number and signs indicating direction in suburban trains and urban rail system vehicles are also placed.

Whether the towing vehicle is a locomotive or an automotive, the following illuminations are made in the driver's cabin.

- Driver control cabin lighting.
- Illumination of the driver's control panel

The driver's control cabin is illuminated by a lamp on the roof. There is also an adjustable beam lamp so that the driver can read some text at night. Gauges and malfunction indicators in the driver's control cabin are illuminated from the inside so that they do not catch the driver's eye.

In double cab locomotives, the engine room is also illuminated. This lighting makes it easier for the driver to move from one cab to the other, as well as assisting the driver when searching for a fault.

The passenger compartments of automatrices and train trains derived from automatrices also need to be illuminated. Fluorescent lamps are mostly used for passenger compartment lighting. Fluorescent luminaires are placed longitudinally to provide a beautiful appearance and a homogeneous light level. In addition, in the event of a power failure in the supply line, auxiliary circuit lamps can be placed to provide lighting at a certain light level, as well as lighting is provided by operating some of the same fluorescent lamps in half-circuit. Again, door threshold lamps are placed on the top or sides of the door so that passengers can easily see in front of them.

Lighting is usually powered by a battery. It is known that battery packs give DC voltage and fluorescent lamps work with alternating voltage. Current converters (converters) that convert DC voltage to AC voltage are used to feed these lamps.

11.5.6.4 DOORS AND CONTROLS

The opening and closing of the doors of modern diesel and electric automotrices and train trains derived from them are carried out automatically. The doors of electric suburban train trains and urban rail vehicles are wide, two-leaf sliding type doors to provide ease and speed in boarding and alighting of passengers. The opening/closing mechanisms required for opening and closing the doors can be pneumatic or electric.

The following safety systems have been developed for passenger safety in suburban train series and urban rail system vehicles.

The train cannot move until all doors of the train train are closed.

The doors cannot be opened until the train sequence comes to a complete stop.

When passengers board, all doors are controlled by photocells to prevent the door from closing so that passengers are not trapped between the door wings.

A lamp/display in the driver's cab shows whether the doors are open or closed.

Passengers are warned audibly for 3 seconds that the doors will close.

In both urban and suburban rail systems, passenger boarding and alighting must be very fast. In such vehicles, the number of doors and door widths are determined according to the total number of passengers getting on and off at the stops (stations). Calculations are made to take into account that a total of 90 passengers will get on/off in 1 minute through a 1-meter door.

11.6 HEATING-VENTILATION-COOLING SYSTEMS (HVAC)

In modern train series, heating, ventilation and cooling systems are applied to ensure passenger comfort. Especially in cities with very hot summers, the Air-Conditioning system has become a necessity in today's living conditions in these series. Air-Conditioning system is also applied to passenger wagons pulled by locomotives today.

In the old days, modern diesel automotives and train trains were heated by blowing hot air. This hot air was supplied by a device called "Webasto", which runs on diesel fuel, or by the cooling water of the diesel engine.

In electric automotrices and train trains, heating is provided by electric resistors (resistances). In modern automotrices and train sets, resistances are placed in air ducts and hot air is blown by blowing fans.

In order to ensure a comfortable journey in summer, cooling groups are also used. These groups provide cooling in summer and heating in winter by blowing hot air from the ceiling. In order to ensure a certain ambient temperature in the places where passengers travel, control is provided by temperature sensors (thermostat).

The air in the passenger compartments must always be fresh. For this purpose, fresh filtered air is introduced into the compartment while the dirty air is exhausted by aspirators.

11.6.1 INDICATORS

Each type of towing vehicle is equipped with the following analog-type indicators.

- Tachometer showing the speed of the train, (km/h or mph)
- Pressure gauge showing main air tank pressure,
- Pressure gauge showing the pressure of the brake air line,
- Manometer showing the brake cylinder pressure of the vehicle itself,
- Battery charge ammeter and battery voltmeter.

In addition to these, electric towing vehicles;

- Traction motor Ammeter/Ammeters,
- Voltmeter showing line voltage,
- Ammeter showing the line current,
- Wattmeter showing electricity consumption,
- Other indicators as required.

Diesel-electric vehicles;

- Traction motor Ammeter/Ammeters,
- Diesel engine oil pressure gauge,
- Diesel engine water temperature gauge,
- Diesel engine oil temperature gauge.
- Diesel engine fuel pressure gauge,
- Diesel engine speedometer,
- Turbo/indicator(s) showing the pressure of the turbo(s),
- Indicator showing engine operating hours,

The above-mentioned indicators are placed in the driver's cabin and in a way that the driver can easily see them.

Figure 11.2 Indicators on the control desk of DE 24000 locomotive

11.6.2 LIGHT AND SOUND ALERTS

In order for the driver to recognize a possible malfunction that may occur while the main components related to the towing or braking function of a towing vehicle and the auxiliary components and other components required for the operation of the system are performing their functions, light warnings are placed in the cabin where the driver can easily see them. The most important ones also provide audible warnings.

11.6.3 CONTROLS

While the controls of all main and auxiliary components and traction/brake controls in traction vehicles are carried out by the driver, the controls of suburban train trains, urban light rail vehicles and high-speed train trains, which are products of advanced technology, are carried out automatically with the 'Automatic Train Control' (ATC) system. This system includes 'Automatic Train Operation' and 'Automatic Train Protection' (ATP) systems. In case of a malfunction in the system, semi-automatic or manual control modes are used.

In Automatic Train Control mode, the driver only ensures the closing of the doors and the first movement. Depending on the condition of the road, many operations such as speeds, opening of doors, speed increase for a delayed train to close this delay, shortening of station stops, speed reduction in early departures or extension/shortening of station stop times are performed automatically.

The operation of this system is ensured by trackside equipment (antennas) placed along the line. In the case of trains following each other at short intervals, the system automatically adjusts the speed and braking of the vehicles.

The controls are fed from the battery circuit and each control circuit is protected from electrical leakage or overcurrent by mini-fuses.

11.6.3.1 TRACTION/BRAKE CONTROL

Traction and braking operations are opposite to each other. In this respect, these controls should be located close to each other. There are two types of braking operations in towing vehicles. These are;

- Friction brake,
- It is a dynamic brake.

Traction and brake controls can be done on the same device or on separate devices.

In classical locomotives, the traction control and the pneumatic friction brake and, if available, the dynamic brake control are carried out on separate instruments. (The instrument that controls the pneumatic friction brake is called the engineer's cock in railways). Later on, traction control was performed on one instrument and pneumatic friction brake and dynamic brake control were performed on another instrument in combination. That is, the pneumatic friction brake and the dynamic brake work together in an integrated manner. However, in modern rail vehicles, the combination of traction, friction brake and dynamic brake is done with an instrument at the driver's disposal. Since the dynamic brake loses its effect below a certain speed limit, braking is continued with the friction brake.

Traction control is also called valse. The pneumatic brake lever used for braking the train is called Machinist's Faucet. The pneumatic brake lever used for single locomotive is called "Modrabl".

In modern train sets, the traction and brake controls are provided by only one lever. The gradual forward movement of the lever is the traction control and the gradual reverse movement of the lever is the brake control. Brake control is a combination of friction and dynamic brake control.

11.6.3.2 CONTROL OF AUXILIARY COMPONENTS AND OTHER COMPONENTS

Auxiliary components and other components are controlled by means of buttons, push buttons and switches. They are placed as far as possible within easy reach of the driver and are internally illuminated so that they can be seen clearly at night. The component that each button and switch controls is identified by a nickname in letters and numbers.

11.6.4 SPEED SENSORS

Skidding, wheel slippage and speed differences between wheels in towing vehicles are factors affecting adherence. Poor adherence causes the traction force to decrease. Prevention of such events is provided by speed sensors.

Speed sensors are located on the driven wheels and are also called 'axle generators'. The axle generator is a small electric generator, which is driven by the rotational motion of the wheels. Different voltages are generated in the axle generators due to speed (revolution) differences that may occur due to skidding of the wheels. These voltage differences warn the driver by activating light and sound warnings.

11.6.5 LOAD SENSORS

In modern rail system vehicles, especially in suburban, metro, light rail, trams and high speed train trains produced in recent years, the vehicles that make up the series are equipped with load sensors.

We know that there is a relationship between the wheel braking force and the weight of the vehicle so that the wheels of a vehicle do not slip during braking. During braking, if we keep the braking force constant and reduce the load , skidding events occur. In the above-mentioned rail system vehicles, especially in urban rail system vehicles and suburban vehicles, the number of passengers is constantly changing. Since this passenger variability affects the vehicle weight, the wheels may skid when there are few passengers. To prevent this, load sensors are installed in the vehicles. Load sensors send the vehicle weight to the microprocessor system and the braking force is adjusted depending on the vehicle weight and the wheels are prevented from skidding.

11.6.6 PROTECTION AND SECURITY SYSTEMS

A number of safety measures have been taken to prevent harm to people or to secure the train against undesirable events that should not be in the course of the towing vehicles, except for some defective behaviors, passengers or the driver's fault. These measures that ensure the safety of travel are realized automatically or manually (manually).

11.6.6.1 TOTMAN (DEAD MAN SYSTEM)

In case the driver dies or faints during the travel of the towing vehicles, a safety system called 'Dead Man' (Dead Man = Totman) system is installed on the towing vehicles in order to secure the train. This system is of two types; Passive Totman and Active Totman.

In the passive Totman system, the driver can drive the train

- Continuously presses a foot pedal or a hand button.
- Or it presses a foot pedal or a hand button periodically.

If the driver is dead or unconscious, the system first sounds an audible warning after a set time (6-7 seconds), assuming that the driver will be distracted, since the foot pedal or the hand button cannot be pressed. If the driver is actually dead or unconscious, the system is activated.

In the active totman system, the driver performs the following actions during the course of the train,

- It controls the traction and brake for acceleration or deceleration and stopping,
- The whistle blows,
- If it does not need to do this, it presses the hand button or foot pedal and pulls.

These actions indicate that the driver is healthy. If the driver does not perform these actions, the system will first give an audible warning after a certain period of time, assuming that the driver will be absent-minded, and if the driver is actually dead or unconscious, the system will activate.

Whether in an active or passive dead man system, the following events occur when the system is activated.

- The towing vehicle and the wagons behind it automatically switch to emergency braking.
- Automatic sandblasting to shorten the braking path.
- In diesel traction vehicles, the engine speed drops to idle, cutting traction power.
- In electric towing vehicles, the main circuit breaker opens the circuit and de-energizes the vehicle.

11.6.6.2 HELP BRAKES

In the passenger cars of conventional passenger trains and in the passenger compartments of automotrices and train sets derived from automotrices, there are emergency flaps to be used by passengers in case of necessity. Braking occurs when these valves are pulled by passengers.

There are also emergency brake buttons in the driver's cab to be used in case of danger. In the event of the driver being absent-minded or dying, the train is put into emergency braking by pressing a distress flap or distress button operated by another person in the driver's cab.

11.6.6.3 AUTOMATIC TRAIN BRAKING SYSTEM (ATS)

On lines where train traffic is managed by light signals, the system that automatically catches the train if the driver passes the red signal due to absent-mindedness is called 'Automatic Train Stop System' (ATS). Braking also occurs when this system is activated.

11.6.6.4 PASSENGER WARNING SYSTEMS

In addition to protection and safety systems, the following systems are also applied to urban rail transportation vehicles, suburban trains and high speed trains.

- Public announcement systems (PA = Public Announcement) : Systems that warn passengers audibly before the train arrives at the station.
- Closed circuit television system (CCTV) : Screen to allow the driver to see what is happening inside the train or to check for abnormalities in front of the doors before departure.
- Digital notices : Digital signage showing passengers which station they have arrived at, this system works in integration with the announcement system.
- Horns and warning bells : Air-operated horns and horns with different tones and sounds in towing vehicles,
- They are warning sounds that indicate that the vehicle doors will be opened or closed.

SECTION:3 TOWED VEHICLE INFORMATION

12. ECM Regulation

ECM stands for "Entity in Charge of Maintenance" and is translated into Turkish as "Entity Responsible for Maintenance". ECM refers to the organization that is fully responsible for the maintenance status of the rolling stock.

Turkey is a member of OTIF, the Intergovernmental Organization for International Transport by Rail. Turkey ratified the COTIF issued by OTIF in 1980 in 1985 and the 1999 protocol amending the COTIF in 2005 with the laws enacted by the Turkish Grand National Assembly. In 2012, OTIF issued Annex A of the ATMF to COTIF 1999 and entered into force in 2013. As of the date of entry into force (01.06.2013) of this document containing the ECM regulation, freight wagons that have not been assigned a certified ECM are not accepted on the lines of the countries that are parties to COTIF and the member states of the European Union.

The DUs (railway train operator) ensure the safe operation of freight wagons in international traffic on the basis of the following two regulations:

- The technical design and manufacture of the wagon shall comply with the applicable UTP/TSIs (WAG and NOI) and this shall be assessed and approved by an Assessment Body independent of the manufacturer, the owner, the DTI and the DIA (Rail Infrastructure Operator). The conformity of the technical design and manufacturing shall be checked by an independent Evaluation Body throughout the process leading to technical acceptance.
- The wagon must be properly maintained. For this, the wagons must have an ECM assigned to them.

OTIF member countries should be able to be sufficiently sure that the freight wagons that will operate on their lines are well manufactured and maintained. It is not possible to determine the exact technical condition of the wagon by wagon technician/revisor checks at border crossings. Harmonized international rules for the manufacture and maintenance of wagons are therefore necessary. The ECM regulation is one of the harmonized international rules for the maintenance of freight wagons.

The ECM Regulation contains requirements and methods for assessing the competence of units responsible for the maintenance of freight wagons. The scope of the ECM Regulation is limited to freight wagons. The OTIF ECM Regulation is equivalent to the relevant European Union regulation 445/2011 EU. Certified ECMs under the European Union regime are equivalent to certified ECMs under the OTIF regime. ECM Certification bodies may also carry out assessments and certifications in all OTIF Contracting Parties, whether or not they are members of the OTIF. An ECM certificate is valid in the European Union and in the countries that are parties to the OTlF. Even if the ECM Regulation is only for freight wagons; in the European Union, an ECM must be assigned to each vehicle under the Safety directive and ECM information must be entered in the NVR (national vehicle register).

The main reason for the introduction of ECM Regulation is to ensure operational safety in the liberalized railway sector. In addition, the benefits of ECM are reduced maintenance costs, improved quality understanding in the organization, increased productivity, effective management with effective monitoring and control, and reduced customer complaints.

The duty of the ECM is to ensure that the freight wagons for which he/she is responsible for maintenance are maintained according to the maintenance file prepared in accordance with the UIC/UTP/TSI requirements, taking into account the applicable maintenance rules, and to ensure that the wagons in question can operate safely when operated by any train operator.

The duty of the ECM starts with the acceptance of the freight wagon produced in accordance with the UNs to the operation as the competent authority and its registration in the NVR. It should not be inferred from this that there is no need to assign ECM to freight wagons which are not in conformity with the UTPs. It is mandatory to enter the ECM of any rolling stock during its registration to the NVR.

12.1 Certification Processes

The procedures and principles for obtaining an ECM Certificate are regulated by an application guide published by the Ministry in October 2017. The guideline explains the ECM application, assessment and certification processes for organizations that will provide maintenance of freight wagons. Apart from the existing ECM application for freight wagons, for other rolling stock, the unit(s) responsible for maintenance authorized by the ministry must be designated by the owner of the vehicle and the maintenance must be carried out by these units.

Applicants apply to the certification body to obtain an ECM certificate. The authority to issue ECM certificate has been given to UHDGM within the framework of the COTIF agreement. In this context, the certification body can be UHDGM or one of the organizations published on the ERADIS website.

In order to obtain an ECM certificate, it must prove that it meets the requirements set out in the ECM Regulation. In order to prove this, it is expected to apply to a certification body for audit and certification. The organizations that can apply for ECM certification are listed below:

- Wagon manufacturer,
- Railway train operator,
- Railway infrastructure operator,
- The person or legal entity who has the right to use the wagon
- Wagon maintenance workshops.

12.2 Maintenance supply certificate

The maintenance supply function is the technical execution of maintenance tasks ordered for the rolling stock. This function can be performed in maintenance workshops. The Fleet Maintenance Management function covers the management of maintenance orders issued by the Fleet Maintenance Management function, the management of facilities, industrial equipment and vehicles, the management of maintenance related technical works.

A Maintenance Workshop is a mobile or fixed asset, including those with management responsibility, vehicles, spare parts, components, other tools used in the assembly of vehicle parts, facilities and personnel.

Figure 12.1 A Wagon Maintenance and Repair Workshop within the Scope of Maintenance Supply

12.3 ECM certificate

Certification means the confirmation by independent third parties that products, processes or systems comply with the required requirements. Certification firms accredited by an accreditation body and recognized by the national railway authority and the national railway authority (NSA) are authorized to issue ECM certificates. An ECM certificate issued by an accredited and recognized certification body or railway authority provides assurance that the certificate holder fulfills the requirements set out in Annex 2 of Annex A of the ATMF. The format of the certificate is defined in Annex 4 of ATMF Annex A.

The players involved in the ECM certification process and the relationship between them are shown in the diagram (ESEN, 2021)

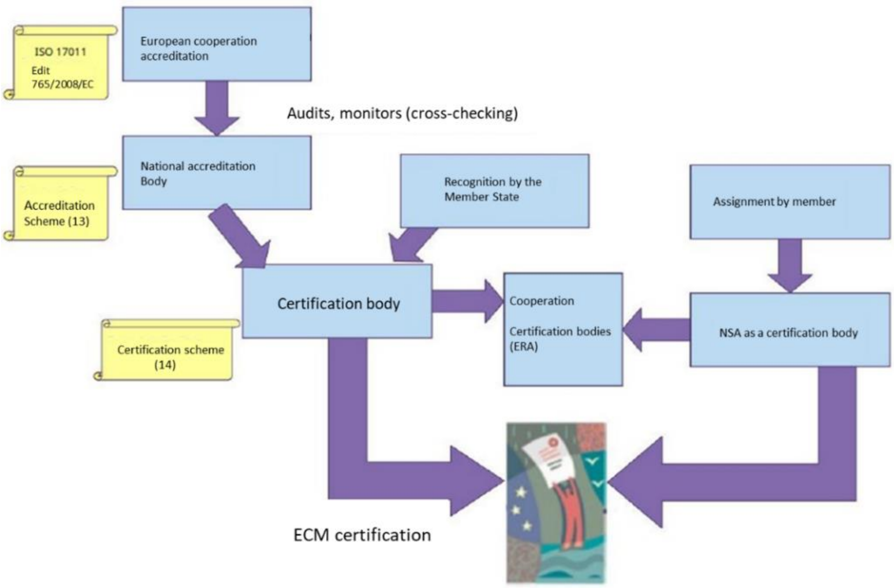


Figure 12.2 ECM Certification process Stages

13. Definitions of International Agreements

13.1 UIC

UIC (Union Internationale des Chemins de fer) was founded in 1922 to create uniform conditions for the establishment and operation of railway administrations. Today, it is a worldwide organization for cooperation between railway companies (organizations) and is active in all areas related to the development of rail transport. As of today, the total number of members is 195, from five continents. Railway Administrations regulate their daily administrative operations such as the manufacture and operation of rolling stock, construction of railways, electrification, signaling, telecommunications, transport plans, financing, accounts and statistics according to UIC standards. For this purpose, the criteria specified in the receipts published by UIC are taken as basis.

13.2 RIC

Regulation on the International Carriage of Passenger Vehicles.

13.3 COTIF

It is the name of the Convention on International Carriage by Rail. It is the basic text of OTIF.

13.4 OTIF

It is an intergovernmental organization dedicated to international rail transport. OTIF was established in 1985 in accordance with the COTIF signed in 1980 (its predecessor was the Central Office for International Rail Freight, founded in 1893). As of 2022, it has 51 members. Its core practice is COTIF and its 7 annexes. Turkey is one of the parties to OTIF.

13.5 GCU

Agreement on mutual uniform use of wagons

13.6 RID

Regulation on International Carriage of Dangerous Goods by Rail

13.7 TSI

(Technical Specifications for Interoperability) TSIs define the technical and operational standards that must be met by each subsystem or part of a subsystem in order to meet the essential requirements and ensure the interoperability of the European Union railway system. All subsystems must comply with TSIs in accordance with Directive 2008/57/EC when they are put into service, upgraded or renewed. The development of TSIs is one of the core tasks of ERA, the European Union Railway Agency. Interoperability is implemented in the Trans European Railway Network (TEN).

13.8 YVBK

Maintenance rules for freight wagons

14. Wagon Types

14.1 Classification of wagons

1) Structurally

a) Load

b) Passenger

2) In terms of business management

a) Commercial

b) Administrative

c) Person

14.2 Passenger car types

Passenger Wagons; Passenger transportation is carried out with various types of passenger wagons offering different services. Different types of wagons have been produced taking into account the demands and needs of passengers. A passenger train consists of different types of wagons such as compartment, pulman, covered or sleeper. While long-distance trains have various types of wagons, short-distance trains have only pulman wagons. Dining cars are only available on long-distance trains where catering is provided. Some special wagons are rented according to the requests of institutions and industrialists and are only available for the use of those who rent them.

Sleeping car: The wagon consists of compartments arranged in such a way that 2 people can travel in them. These compartments have seats that can be converted into beds.

Couchette wagon: The wagon consists of compartments with seats facing each other. When the fixing locks of these seats are unlocked and tilted, beds are formed inside the compartment. In addition, the passengers are provided with covers and pillows and put into service as "covered couchette". More passengers can travel than in sleeper cars.

Pulman carriage: The seat system in this carriage usually has a 2+1 pulman system. There are pulman wagons in every train and some trains have only pulman type wagons. These seats, where passenger comfort and safety are considered, are reclinable, ergonomically designed and have wide spacing. There are folding tables behind the seats.

Dining car: The dining car is used only as a dining area and is not used for passenger transportation. The appearance and design of the car is the same as the restaurant concept. Inside the carriage, there are 2 seats opposite each other and a table in the center. The table is big enough for 4 people to use comfortably.

Wagon with compartments: A wagon consists of compartments with seats opposite each other that cannot be made into beds.

Suburban wagon: Used for short-distance travel, these wagons have less seating and more standing room.

Passenger car: Wagons used by train personnel and can carry luggage.

Lounge car: These are wagons rented for business trips and special occasions. They are specially designed wagons with lounge, bathroom, kitchen, bed compartment and WC.

Conference wagon: Specially manufactured for the use of industrialists and businessmen during their travels.

Generator Car (D+J): Wagons with electrogen groups as train heating energy source and also with a furgon compartment.

14.3 Freight wagon types

Freight wagons are grouped as closed, open, platform, heavy and cistern wagons.

15. Wagon Main Parts

Vehicles that are produced and maintained according to railway technical standards and are used to carry passengers and freight are called WAGON.

15.1 Chassis

Since the chassis, which forms the skeleton of the wagon, is between the moving and stationary wagon parts, it is affected by both the road and other vehicles. For this reason, chassis are made of high strength 'U' or 'H' putrels. Putrels are connected to each other by welding, rivets or bolts. Under each of the cross members at the head of the chassis, two handrails are placed for maneuverers and these handrails consist of steps and handles.

15.2 Safe (chest)

Crates are produced in different shapes such as open, closed, platform, cistern according to the characteristics of the cargo to be transported. The crate consists of parts such as skeleton, floor slabs, side wall struts and strut supports, doors and windows, unloading device, parator, stairs, railings. On the side walls, there is a place to put labels in the lower left corner.

15.3 Wheel Set

It transports masses by rolling on a track at a certain angular speed. It consists of a wheel set, an axle and two wheel bodies. The wheelsets of TVS 2000 type wagons are also equipped with brake discs.

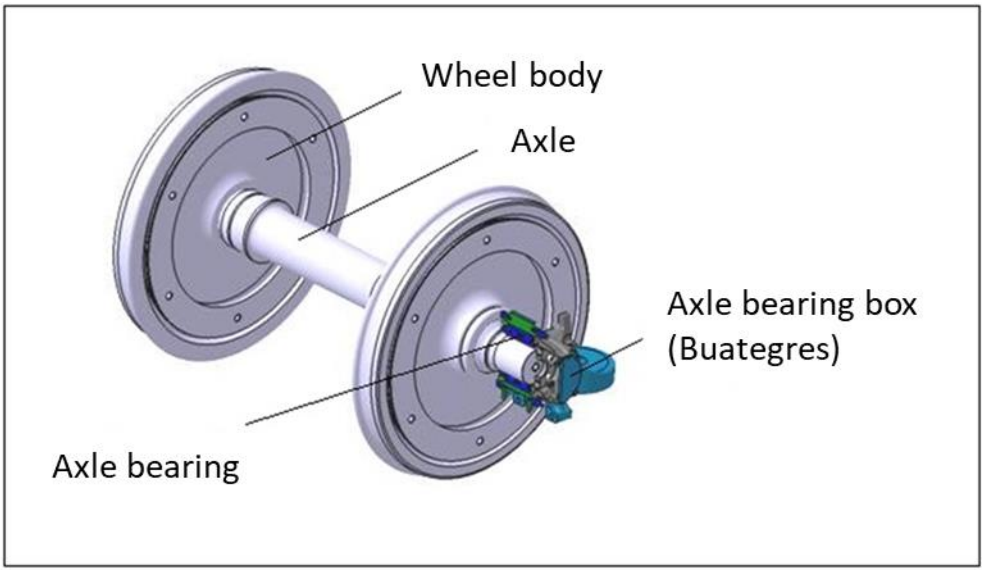


Figure 15.1 Wheel set

A wheelset is created by subjecting it to the following processes:

- The axle is prepared in appropriate dimensions.
- Wheel housings are tightened to 0.25-0.40 mm. with press power.
- Axle bearings are inserted into the axle heads by heating or pressing power.
- Axle boxes (buategres) are mounted to cover the bearings.
- Wheel diameter differences and runouts are eliminated by turning.

Wheel bodies are manufactured as monobloc (single body or solid body) and are used up to the operating limit line. Wheels whose diameter decreases up to the operating limit line are removed from the axles and replaced with new ones. Axles, on the other hand, can be used many times if there is no malfunction that prevents their use.

Figure 15.2 TVS 2000 type wagon wheel set

15.3.1 *Axle bearing*

Axle bearings take the weight of the wagon and transfer it to the axle heads (turions). In the past, plain bearings were used, but nowadays rolling bearings are used.

Figure 15.3 Axle bearing and axle box (cover removed)

15.3.2 Axle box

The axle box (buategres), located above the bearings, stores the bearings and axle bearing oil and protects them from external influences.

15.4 Wheel Arrangement

According to their wheel arrangements, wagons are produced in two different ways: axle and bogie. Passenger wagons and wagons for carrying heavy loads are produced with bogies, while wagons for carrying light loads are produced with axles.

15.4.1 Axle wagons

They are generally produced with two axles and leaf switchblade. The axles are directly connected to the wagon chassis with a suspension system. The basic element of the suspension system is leaf switches.

In axle wagons, vibrations caused by movement are transmitted from the chassis to the hanger sports, from the hanger sports to the fasteners and sustains, from the sustains case to the axle box and axle bearing, from the axle bearing to the axle head and axle, from the axle to the wheels and rail. The transfer of knocks and vibrations from the rails to the wagon frame and the load takes place in the reverse of the above process.

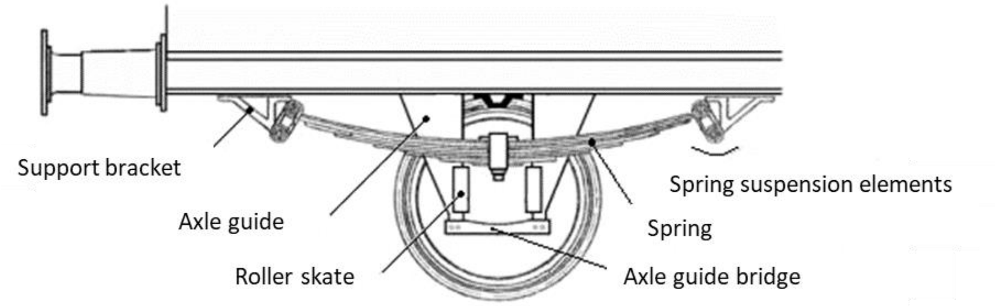


Figure 15.4 Wheel connections of a wagon with axles

Figure 15.5 Connections of a wagon with axles

15.4.1.1 Axle fork (plakdögard)

It provides the connection between the chassis and the wheelset. It guides the movements (up-down or inside-outside) of the axle box. Connected to the chassis by welding or rivets.

15.4.1.2 Axle fork bridge (braga):

Connects the axle fork under the axle box. It prevents the axle fork from opening and breaking due to the forces occurring during take-offs, stops and curves.

15.4.1.3 <u>Hanger (susta) sport</u>:

It is joined to the wagon chassis by rivets or welding. It allows the leaf switch to be connected to the wagon with fasteners.

15.4.1.4 <u>Leaf silences:</u>

Sustalar wagons absorb some of the vertical forces and vibrations. They are used in axle wagons and some types of bogies. Leaf sustains consist of three parts.

a) Leaves One of the susta leaves is the main leaf and the others are auxiliary leaves. The number of leaves decreases or increases according to susta types. There is usually a canal in the center of the leaves. These canals prevent the leaves from spreading over the width. The main leaf has perno sockets called susta eyes. The susta is connected to the susta sport and therefore to the wagon by means of pernos and menots.

b) Susta casing: Prevents the susta leaves from scattering. The nozzle under the susta casing fits into the slot on the axle box and prevents the susta from moving left and right.
c) Susta wedge Used to compress the leaves inside the susta.

15.4.1.5 Causes of breakage in the susta:

- Tissue fatigue resulting from a certain amount of work,
- A crack in the leaves that may occur for any reason,
- Overloading
- Rust
- Lack of oil between the susta (when there is no oil, the force from the main leaf cannot be transmitted to the lower leaves),
- Slipping of the leaves due to the looseness of the susta casing.

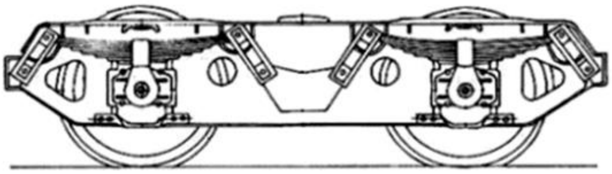
15.4.2 Bogie cars

A transport group consisting of at least two sets of wheels and a chassis is called a bogie (wagon). The chassis of the wagon is mounted on a spherically spherical bogie hub and connected by a shaft called a perno (pivot connection). This spherical play allows the bogie to move freely under the chassis. The bogie frame is made of welded construction or cast steel.

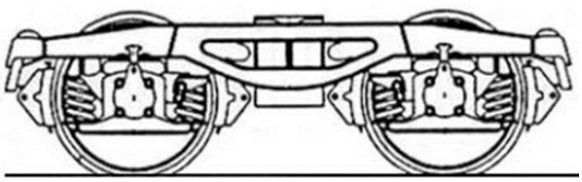
Bogies, in a vehicle:

- Improves suspension, sound insulation and comfort,
- It makes it suitable for high speeds,
- Increases the number of axles, reduces axle pressure,
- It makes it possible to grow taller,
- Increases loading tonnage,

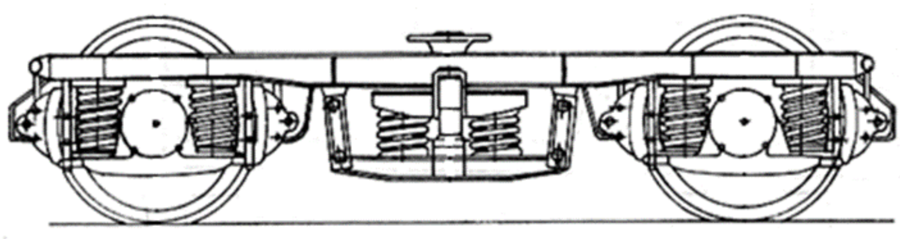
In order to reduce vibrations and provide suspension in bogies, leaf mufflers, spiral mufflers and shock absorbers are used. "Schlieren" and "Y32" type bogies are used for passenger wagons, "Y25" and "UIC" type bogies are used for freight wagons.



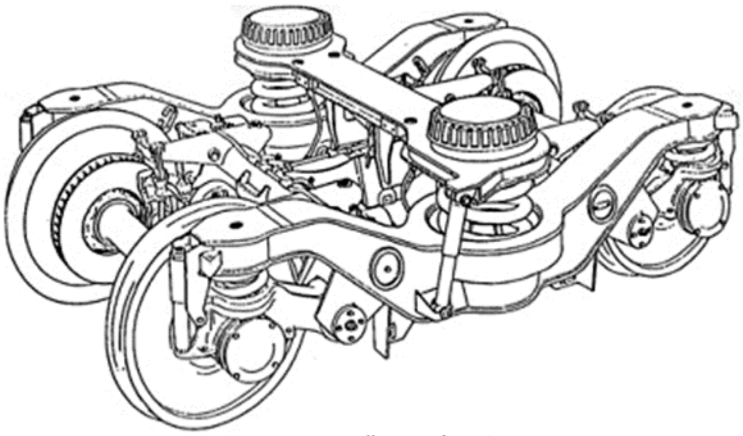
UIC type bogie



„Y25“ type bogie



“Schlieren” type bogie



„Y32“ type bogie

16. Derailed Wagons

Derailment is when rolling stock is off the line.

Major causes of derailment:

- Susta malfunctions (susta broken, loose, susta misalignment, susta connection parts broken)
- Wheel failures (boden thin, boden broken, axle broken, bearing defective, wheel loose, bandage loose, wheel diameters different, etc.)
- Bogie, chassis failures (broken bogie, broken chassis)
- Plakdögart defects (skewed, cracked, missing braga)
- Buffer malfunctions (buffer level low or high, buffer broken or missing)
- Road failures
- Loading errors (excessive and unbalanced loading, gauge overrun)
- Maneuvering errors (severe buffer, no scissor lock, half scissors)
- Apletilik events
- Incorrect sequence formation
- Placing parts on the rail
- Excessive speed
- Carambola (collision)
- Wagon, train escape

Derailed wagons are not put into service without the necessary inspection / control and maintenance in the workshops. Even if no malfunction is detected in the first inspection of these wagons when they are put on the line, they must be sent to the workshop for inspection (as required by GCU and RIC).

In the place where it is even placed, the distance (AR measurement / E Distance) between the wheels (at least 3 points) is definitely measured whether the axles of the derailed wagon are skewed or not.

17. PNEUMATICS AND BRAKE KNOWLEDGE

It is known that people make use of many different devices in order to live a better life and to make their work easier. Different types of energy are used to operate these devices. Heat, electricity, light, mechanical, chemical and solar energy are some of these energy types. It is a reason for preference that energy is easy to obtain, abundant and low cost. Compressed air is an energy that fits these characteristics. It is known that people have been utilizing air, which is abundant in the atmosphere, as an energy source since time immemorial. For example, windmills are among the simplest devices that work with wind pressure.

The power of air to operate mechanisms with the effect of pressure has pushed people to research and develop air-powered systems. The pressure of the air, which is abundant in the atmosphere, has been increased in closed containers, allowing a controlled force to be obtained by acting on mechanical parts. Systems that work in this way, that is, systems that work with compressed air, are called "pneumatic systems".

In almost all areas of the industry, various operations such as tightening, loosening, producing linear or circular movements can be produced more economically and very fast movements when pneumatic systems are used.

17.1 Advantages of Pneumatic System

1. Air, the source of pneumatic energy, can be obtained unlimitedly from the atmosphere.
2. Compressed air can be transported over long distances.
3. Compressed air is not sensitive to temperature changes and can be used safely in hot environments as there is no danger of ignition.
4. The air is clean, leaks will not pollute the environment.
5. Circuit elements are simple and cheap.
6. High speed is achieved. Piston speed can reach (l m/s-2 m/s) values.
7. Safe against overloads.
8. Speed and generated force can be adjusted to different values.

17.2 Disadvantages of the Pneumatic System

1. Due to the compressibility of the energy (air) used in the pneumatic system, it is not always possible to obtain the piston speed at the desired values and to keep it at the same level under all conditions.
2. Without proper lubricants and filters, friction increases and movement becomes difficult.
3. Moisture (water vapor) mixed into the air can cause corrosion when lubrication is not sufficient.
4. Since the normal working pressure is 6-7 bar, the push and pull forces to be obtained in the pneumatic system vary between 2000 kilograms and 3000 kilograms. Since air is compressible, large forces cannot be obtained.
5. Since the air that has completed its task is discharged into the atmosphere through the exhaust line, there is a constant consumption of air, which increases the cost.
6. The air exhausted from the exhaust line into the atmosphere makes a noise that disturbs workers when a silencer is not fitted.

17.3 *Application Areas of Pneumatic System*

Compressed air powered systems have many advantages and have found many uses in industrial life. When choosing the application area of pneumatic systems, the requirements for fast movement but small forces (maximum 3000 kg.), cleanliness and safe operation are generally taken into account.

In railways, compressed air is used to operate the brake systems and auxiliary circuits of towed and towed vehicles. Atmospheric air is compressed in compressors to increase its pressure and filled into tanks. When necessary, the compressed air is passed through the machinist or modrabl taps, the pressure is adjusted, directed by various valves and converted into mechanical power in the brake cylinders and braking is realized by the effect of friction on the rotating wheels. The compressed air can be diverted by valves operated by air pressure, as well as by electric valves that operate these valves. This type of systems are also called electropneumatic systems.

17.4 General Main Parts of a Pneumatic System

The general main parts used in the pneumatic system vary according to the characteristics of the assemblies. It is generally motors that give motion to compressors that produce compressed air. Accordingly, the general main parts that make up the pneumatic system are as follows.

1. Engine,	6. Pressure regulators,
2. Air compressor,	7. Directional control valves,
3. Filters,	8. Speed regulating valves,
4. Oil elements,	9. Cylinders,
5. Pressure control valves,	10. Air storages

18. BRAKES USED IN RAILWAY VEHICLES

18.1 General Brake

Traction power obtained on locomotives is used to move locomotives and wagons used in railway transportation and to ensure speed increases. It is a necessity that these vehicles, which move with traction power, can be slowed down and controlled when necessary and can be stopped at the desired location.

Therefore, in order to reduce and stop the speed of trains moving with traction power, the kinetic energy generated in motion must be reduced and completely destroyed. In other words, in order to reduce or stop the speed of these vehicles, a force must be applied in the opposite direction to the push or pull force of the traction power. This force applied against the movement is called brake force. When the brake force is applied and is large against the movement, the brake is applied.

The braking force is generated by converting the effect of compressed air into mechanical power by a friction force in the opposite direction to the rotation of the wheels. For this, brake pressure parts that prevent the rotation of the wheels are used. According to the above evaluations, we can define the brake as follows;

Brake: The effect that first reduces the speed of a moving vehicle by destroying its driving or pulling power, then stops it and keeps it stationary after stopping it is called a brake.

18.2 Brake Types

A. Auxiliary Brakes
   1. Dynamic brake
   2. Hydrodynamic brake
   3. Magnetic brake
   4. Parking brake installed on susta
   5. Hand brake

B. Compressed Air Brake
   1. Direct acting compressed air brake (modrabl brake)
   2. Indirect-acting compressed air brake (engineer's cock brake)
      a. In terms of impact
         - Slow Acting (G)
         - Series effective (P)
      b. In terms of solving
         - Single solvent
         - Very solvent
   3. Compressed air brake according to friction effect
      a. Sabolu brakes
      b. Pad brakes

18.3 Auxiliary brakes

18.3.1 Dynamic brake

In locomotives driven by traction motors, traction motors are operated as generators (generators) and it is a braking or speed stabilization by creating an electromagnetic resistance against the rotation of the wheels. The traction motors, which rotate the axles through the traction teeth in the traction state, switch to the generator state like an electric motor (dynamo) when the locomotive is switched to the dynamic brake state by the engineer. It receives the driving force from the axles to which it gives motion. The electric current produced by the movement it receives from the axles is used as a counter force that prevents the axles from rotating together with the auxiliary parts.

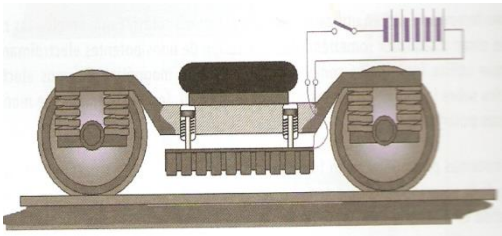
In the case of dynamic braking, the electrical energy generated by the traction motors is first converted into heat energy, and then the heat energy is transferred to the air and destroyed, creating a force against the rotation of the axles. The energy is converted into heat by resistors and the heat in the resistors is transferred to the air by the traction motor air blowers. It is not used to stop the train but to keep the locomotive speed constant. It is a very useful auxiliary brake, especially on ramp descents. It is an economical braking as it has no wearing parts like sabo or lining.

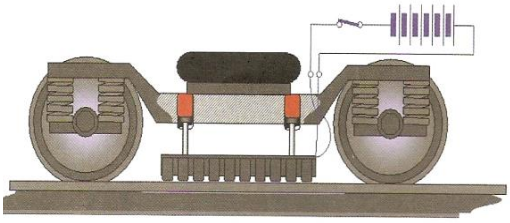
18.3.2 Hydrodynamic brake

This brake system is used in locomotives with hydraulic transmission. In order for this brake to occur, hydrodynamic braking is provided by giving motion to the transmission in the opposite direction of the direction of travel while the locomotive is moving in the forward or reverse position and trying to turn the torque converter in the turbo gearbox in the opposite direction. It is a system that allows the locomotive to brake the locomotive with hydrodynamic braking without using the air brake of the locomotive.

18.3.3 Magnetic brakes

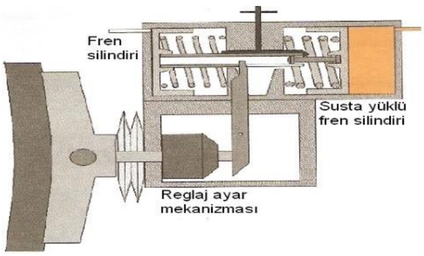
Magnetic brakes used as additional brakes in railway vehicles have nothing to do with wheels. The magnetic brake shoe consists of a powerful electric coil placed in a steel case and iron slides attached under this case. During braking, these shoes are lowered to the rail by electro-pneumatic control and at the same time current is supplied to the coil. With the magnetic power generated by the coil, the shoe sticks to the rail and provides braking of the vehicle. The lifting of the magnetic brake shoe is realized by means of spring power etc. systems.





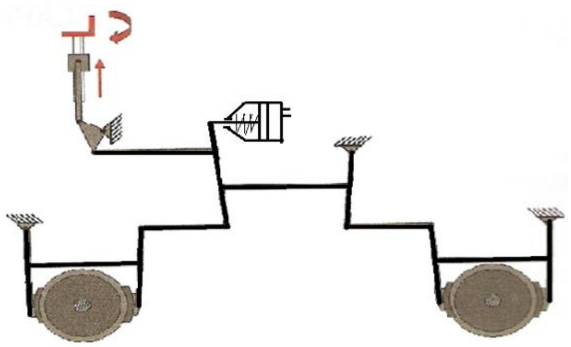
18.3.4 Susta Loaded Parking brake

In this braking, which is used as a parking brake in locomotives using block brake mechanism, it is a brake that is realized by creating pressure on the wheels by the brake pads kept under pressure with compressed air in the brake cylinder loaded with susta. When compressed air is sent into the brake cylinder loaded in the susta, it releases the brake.



18.3.5 Hand brake

It is a brake used to secure towing and towed vehicles in place. It allows hand force to be applied to the brake system on the wheels using a lever, gear system, chain or steel cables. Hand brakes used on wagons are usually braked by pressing a lever and applying handwheels and bevel gears to the center brake or bogie brake system.



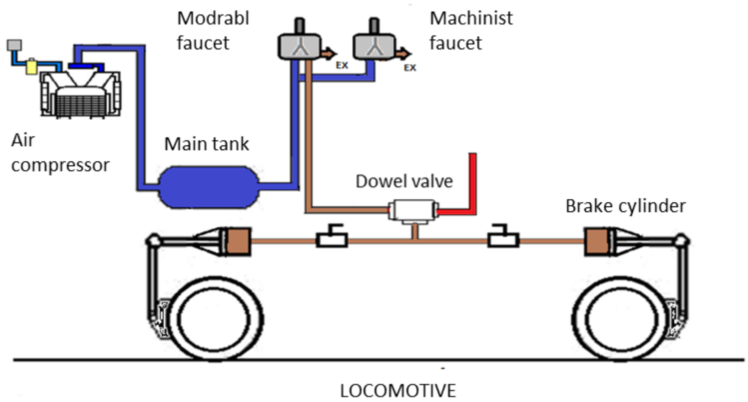
18.3.6 Compressed Air Brakes

Compressed air brakes are generally used in railways. Compressed air is produced by the compressors on the locomotive and sent to the main tanks and stored. The engineer lowers the pressure of the main tank air by means of the engineer's tap and sends it to the conduit line of the wagons. The pressurized condenser air is converted into mechanical power in the brake cylinders by means of three-way taps on the wagons and transferred to the sabots or pads on the wheels. Compressed air brakes are divided into two as direct-acting and indirect-acting in terms of the effect of air on the brake cylinders.

The main type of brake specified by the UIC for braking of trains on railways is the indirect-acting compressed air brake.

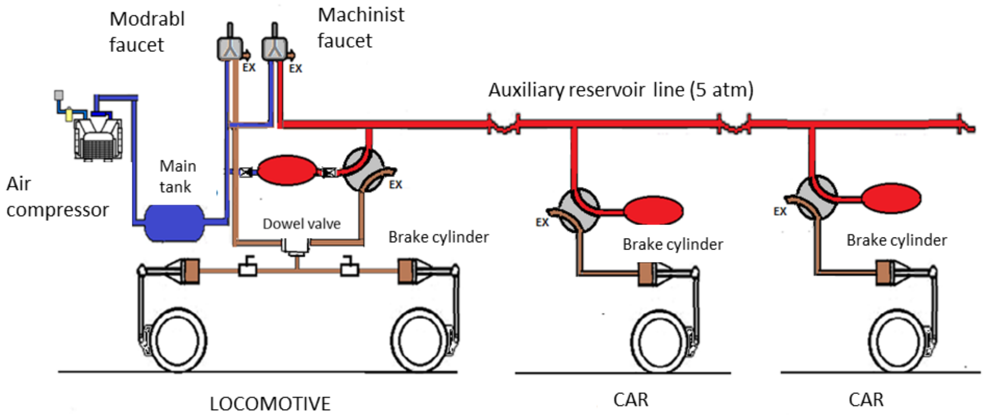
18.3.7 Direct acting compressed air brake

It brakes the locomotive by sending the main tank air directly to the brake cylinders by adjusting the pressure through the modrabl cock and releases the brake by discharging the brake cylinders air to the atmosphere through the modrabl cock. Only brakes or unbrakes the locomotive. It is not used for braking wagons, wagons do not have such a brake system.



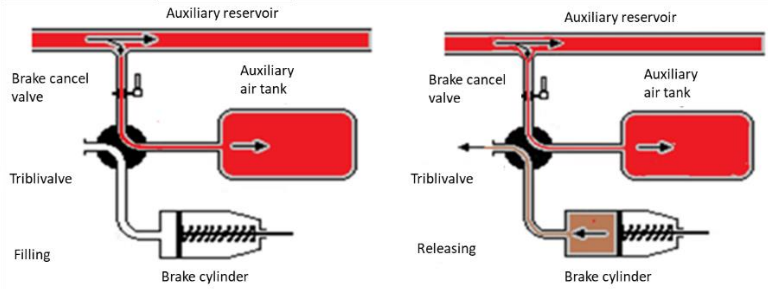
18.3.8 Indirect Acting Compressed Air Brake :

It is an automatic brake formed by the use of condenser air. The main tank air is passed through the adjusting bag of the engineer's faucet and 5 atm.conduit air is formed. A three-way (triblivalf) governing valve is used to bring the indirect brake system into braking and releasing state under the influence of the pressure of the conduit. The main brake used on railways is the indirect-acting compressed air brake, which is automatically applied according to the pressure in the conduit.

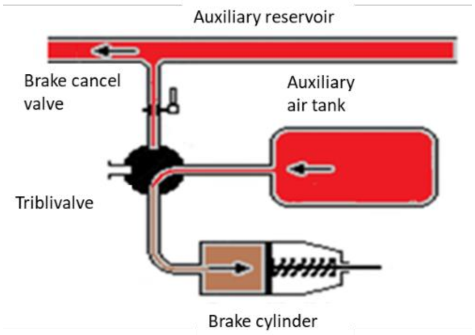


The simple operating conditions of the triblivalve, the applicator of the indirect compressed air brake, are as follows;

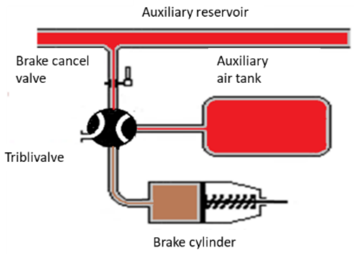
1. Filling and deflating : Fills the condenser air into the auxiliary air tank and at the same time connects the brake cylinder air to the outside through itself.



2. Braking : Provides braking by sending auxiliary tank air to the brake cylinders.



3. Interruption (Fixed) : Disconnects the contact between the condenser and the auxiliary air tank, the auxiliary air tank and the brake cylinder and the brake cylinder and the atmosphere (outside).



a. **In terms of Effect:** It must be ensured that the air sent to or discharged from the brake cylinders by means of the governing valve is in a short or long time. This time period varies according to the load or passenger condition. If the filling or discharging of the compressed air occurs in a short time, that is, if the vehicle brakes and releases the brakes in series, it is called a quick-acting brake, and if the compressed air rises or falls in a long time, it is called a slow-acting brake.
b. **In terms of Dissolving :** If the air in the brake cylinders is discharged from the brake cylinders through the governor valve in a single stage, it is called single-dissolving brake, if it is provided in two or more stages, it is called multi-dissolving brake. According to UIC instructions, multi-release governing valves must be used on trains.

18.3.9 Compressed Air Brakes by Friction Effect

After the compressed air effect is converted into mechanical force in the brake cylinders, this force is transmitted to the friction parts by means of brake rods. The friction parts usually exert a stopping effect on the wheels by creating a reverse friction and stopping force.

a. **Sabolu Brakes :** They are the most commonly used brakes in railway vehicles. It is a brake system that allows the friction force generated by the friction of the brake shoes called sabo against the wheel rolling surface to be used as brake force.
The pressure of the sabo on the wheel is provided by a pressure force. If this pressure force is provided by hand, it is called a hand brake, if it is provided by compressed air, it is called a compressed air brake. Sabolu type compressed air brakes are used as the main braking means in railway vehicles. Brake shoes, which we call sabo, are manufactured from cast iron or mixed products (composite) by giving a special shape. Sabos are manufactured in 60 mm. thickness and are changed when the thickness drops to 10 mm.

b. **Pad Brakes:** In **this** type of brake, the pads press on a drum or disk connected to the wheel axle, also known as a disc brake. The pads press the drum or disk with the effect of compressed air. Generally used on high-speed vehicles. They last longer than sabos.

18.3.10 Definitions of compressed air brake technique

- **Nominal pressure:** It is the pressure of the conduit in the released brake. According to UIC instruction this value is 5 kg/cm^2.
- **Multi-resolution brake:** A brake is multi-resolution if the triblivalve allows the **brake** cylinder pressure to be gradually reduced. According to UIC regulations, only multi-resolution brakes are permitted for international transportation.

- **Replacement weight:** The sum of **the** tare **of the wagon** and the partial load. It is shown in tons on the brake weight plate.
- **Tank filling time:** The time from when the pressure in the **control** cell and the import tank (or auxiliary tank) starts to rise until it reaches 4.8 kg/cm^2.
- **Brake weight:** Reports the weight of the brake in tons. This is calculated according to the ULC instructions.
- **Specific sabo pressure:** The pressure force on a l cm^2 sabo surface.
- **Braking ratio:** The ratio of the total sabo force to the wagon weight (i.e. tare or total weight) as a percentage.
- **Brake cylinder deflation time:** After a complete operating brake, the time from when the pressure in the brake cylinder begins to drop continuously until the pressure drops to 0.4 kg/cm^2.
- **Brake cylinder fill time:** The time from when the pressure in the brake cylinder starts to rise until it reaches 95% of its maximum value.
- **Leakage compensation:** Compensation of pressure losses caused by brake cylinder or piping leakage by the triblivalve.
- **Full operating brake (full brake) :** occurs when the condenser pressure is reduced from 5 kg/cm^2 (nominal pressure) to 3.5 kg/cm^2 without interruption. The brake cylinder pressure then rises to its maximum value.
- **Stage operating brake:** Occurs when the condenser pressure is gradually released. The stages can be continued until the condenser pressure is reduced to 3.5 kg/cm^2, thus obtaining the maximum brake cylinder pressure.
- **Emergency brake:** A series brake that moves the emergency brake assembly to completely relieve the pressure in the conduit and to allow the brake cylinder pressure to reach its maximum value in a short time.
- **Filling with more pressure than the nominal pressure:** This is when the condenser and import tanks remain filled with pressure above the normal pressure of 5 kg/cm^2.
- **Automatic pressure protection:** If pressure losses are automatically compensated by the triblivalve, the brake is automatically pressure maintained. In this case, the brake cylinder pressure is maintained at the same value despite leaks.
- **Automatic acting:** Every indirect brake is automatic. In case of cataract rupture, a series brake is automatically applied by releasing the pressure in the conduit.
- **Inexhaustibility:** A brake that does not show a pressure less than the normal upper pressure of the brake cylinder in a series of brakes at the end of these phases, even if frequent and quick braking and unbraking are performed in succession, is an inexhaustible brake.
- **Series brake:** Occurs when the condensate is completely evacuated over a large cross-section. The brake cylinder thus reaches its maximum pressure in a short time.

18.3.11 Comparison of pads and lining brakes

18.3.11.1 Effect of type and shape of sabo on braking

In braking with a single sabo, which was practiced in the past, the thickness of the surface of the sabo rubbing the wheel changes as a result of heating and a certain side of the sabo contacts the wheel. In this case, the specific sabo pressure force increases and the coefficient of friction between the sabo and the wheel decreases. The coefficient of friction between the wheel and the sabo is not very high in sabos made of artificial materials, bakelite or similar additives. For example, in order to provide a braking path of 700 meters, a wagon sabo with a braking rate of 80% can reach 105 km/h if it is made of plastic and 120 km/h if it is made of artificial material. However, when artificial material is used, wetness affects the coefficient of friction very much.

Sabos with parts consisting of a sabo shoe and a sabo gave better results than sabos in one piece. Since the heated sabo is pushed to the wheel through the shoe (sandal), it contacts the wheel with its whole face.

By shortening the length of the sabo, the change in the thickness of the sabo due to heating was prevented. The speed gain provided by using a piece and short length sabo compared to a single piece sabo was 2.9 km/h at 80% braking and 3.3 km/h at 130% braking. Although the length of the shoe provided some benefits, it had an adverse effect on the consumption of the shoe. For this reason, double sabo connected to the same brake shoe was used. In this way, the speed gain was 5.5 km/h at 80% braking rate. In addition, there are no breakage and cracking incidents in double sabos. Since the sabo sits on the wheel with its whole face and this situation does not change as a result of heating, double sabo should be used in wagons built for high-speed trains.

18.3.11.2 The drawbacks of sabolu brakes;

1. Heavy workmanship due to the heavy weight of the sabo and its frequent replacement,
2. Harmful to health due to excessive iron dust,
3. Causing noise pollution,
4. Large variation of the coefficient of friction with speed,

18.3.11.3 Advantages of lining brakes;

1. It is easy to work due to its light weight,
2. Noiseless operation,
3. Labor savings as it needs to be changed over long periods of time,
4. The coefficient of friction between the pad and the disk does not change much.

Since the coefficient of friction of the lining becomes much smaller with wetness, it is preferred that the lining presses on a pulley or disk located in a closed place on the axle instead of pressing on the wheel bandage. Since this disk is located on the axle, the axle is forced against both bending and buckling. For this reason, the axle should be made of alloy steel with 80-100 kg/mm^2 strength. In addition, it is desirable that the pad does not eat the brake pulley, is resistant to abrasion, and is not affected by heat and wetness.

19. TOWED VEHICLE BRAKING AND PNEUMATIC SYSTEMS

19.1 Components of the Wagon Brake System

19.1.1 Pneumatic parts

Parts under the influence of compressed air;

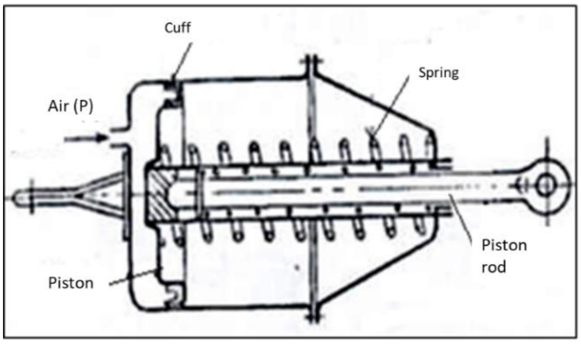
1. Main conduit line
2. Brake cylinders
3. Air shut-off taps
4. Purifier
5. Air hoses
6. Emergency brake device

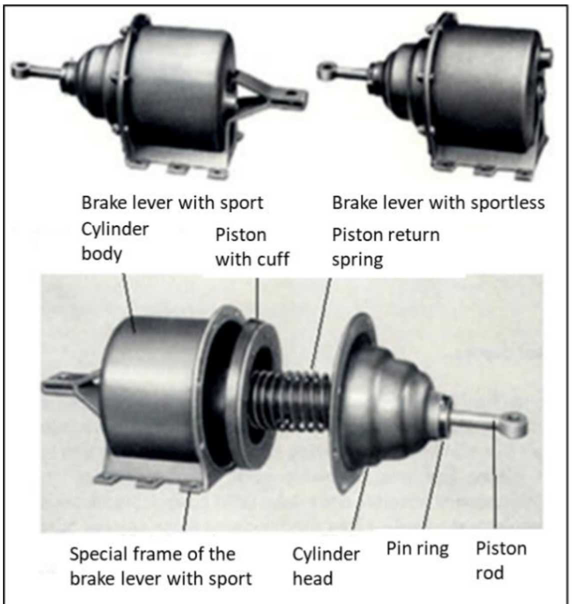
7. Open-close assembly
8. Auxiliary air (import) storage
9. Dust bags
10. Brake systems and triblivalves

Main conduit line: This pipe, through which 5 atmospheres of compressed air passes, goes through the carriage and goes up to the air taps on the buffer sleepers. The compressed air supplied from the air compressors on the locomotive is sent from here to the main tank of the locomotive and from there, under the control of the engineer, it is passed through the pressure regulator and sent to the conduit at 5 atmospheres. This passage to the train is provided by the main conduit pipe, acerman taps and air hoses.

There should be 5 atm. of air in the condenser line for braking and theoretically there should be no air leakage. However, since this may not be possible for various reasons, there should not be more than 0.5 atm. air leakage in one minute on a 100-axle freight train and 0.3 atm. air leakage in 1 minute on a passenger train. If the air leakage is more than this, the leakage is searched and eliminated. Air leakage is checked from the conduit manometer on the locomotive and furgon. Air leakage is searched at pipe joints, taps and hoses. Foam is used for this. Wagons with broken or cracked main pipes are removed from service.

19.1.2 Brake Cylinders





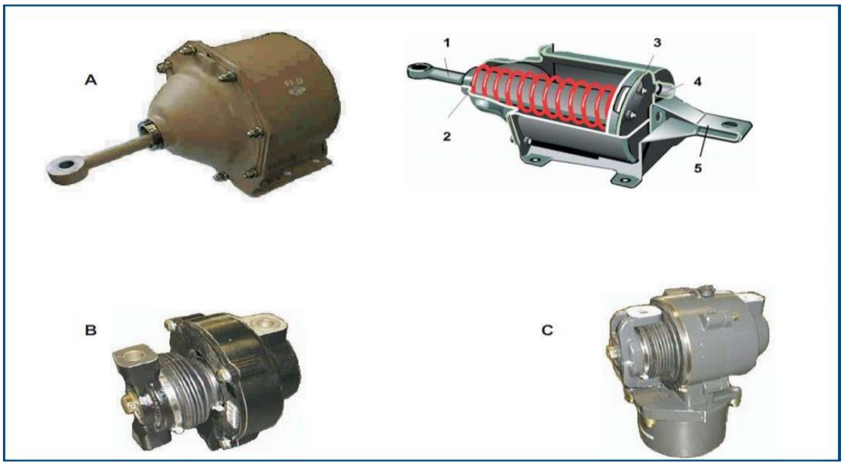
Steel brake cylinders and parts

The main source of the force transmitted to the wheels is the brake cylinders, where compressed air is converted into mechanical power. The compressed air acting on the piston surface, together with the piston and the rod connected to it, transmits the force through the brake rods to the sabots or pads.

Brake cylinders are made of cast iron or sheet steel in standard diameters of 8", 10", 12", 14", 16", 20" (inch). Sheet steel brake cylinders are 50% lighter than cast brake cylinders.

A special sport is used to connect the brake cylinder to the wagon. The brake cylinder is connected to this sport and the sport is connected to the wagon frame. It is possible to rotate the brake cylinder in the sport in order to ensure good pipe connections, A sport is placed behind the brake cylinder for the connection of the brake lever, and there is also a sportless version for use where it is not needed. The return spring is placed inside the brake cylinder.

The brake cylinder is sealed with a leather or rubber cuff (tab) attached to the brake cylinder piston. The piston rod is manufactured to be removable so that it does not drag the piston with it when the hand brake lever moves. When the brake is released, the levers are retracted by the lever spring force. The brake cylinder cover can be easily dismantled as the pressure switch behind the piston is not stressed when the brake is released.



19.1.3 Air Shut-off Taps (Akerman Taps)

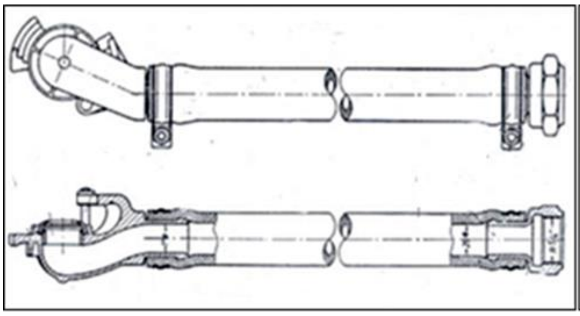
Akerman tap

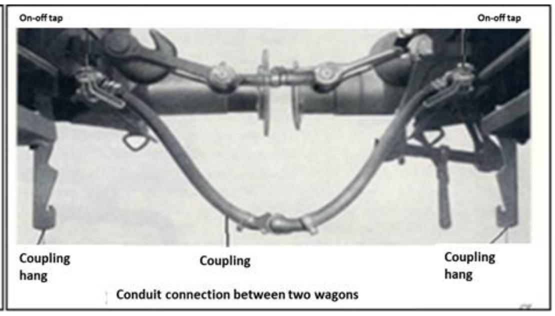
At each end of the wagon there are air shut-off taps of a ***known and valued*** type. The rotating part of the tap, spherically shaped, presses on a rubber washer in the closed position and closes the conduit securely. At the same time, the air in the brake accumulator is discharged through the rubber valve seat. In this way, when the taps are closed, the tubing can be released without danger as there is no pressure in the tubing hoses between the two wagons. The lever of the shut-off tap is vertical upwards in the closed position and in the open position in the direction of the fluid. Since the tap is not affected by dirt, it can easily operate for years without maintenance.

19.1.4 Purifier

It is a device for manually bleeding the brake cylinder air through the triblivalve. It allows the brake cylinders to be bled manually in order to ensure that a wagon whose brake is not released can travel without brakes in the train. When the brake is held, the purge valve is not pulled. If the air shutter is defective, it leaks air continuously.

19.1.5 Air Hoses





The air hoses are screwed into the screwed parts of the shut-off taps at both ends of the wagons and secured and closed with a hexagonal lock nut. Conduits are connected to each other by means of the couplings between the wagons, and the unused couplings are attached to the hanger they belong to in order to prevent dust from getting inside.

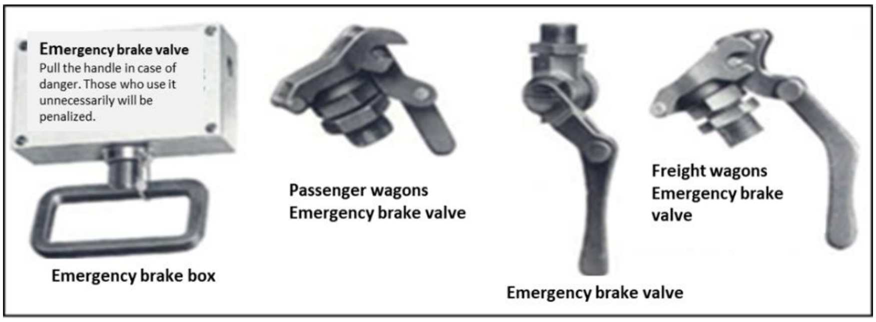


Figure 19.1 Emergency Brake Assembly

Automatic compressed air brakes are preferred because they can be operated from anywhere on the train. In case of danger, it is possible to stop the train at the shortest distance with the help of the emergency brake device. A series brake is applied by discharging the condensate out of the large hole through the valve or faucet. It is obligatory to have emergency brake boxes in every passenger wagon. In case of danger, the sealed hand grip on the emergency brake box can be pulled out, but it cannot be put back in place by the passengers. In this way, it is clear from which location the emergency brake was applied. The emergency brake box is connected by a thin wire rope to the emergency brake valve on the conduit. As soon as the emergency brake is applied, the cover of the emergency brake valve suddenly opens as if it bursts open and opens the conduit over a full cross-section. When the lid closes again, the wire rope is pulled taut again and the lever of the emergency brake box then snaps into its original position. In freight cars with a brake box, an emergency brake cock is installed in the conduit. This is controlled by a lever in the brake box. The tap can only be closed again after the train has stopped by turning the lever directly. Foreign railroad companies use emergency brake valve instead of emergency brake cock. Although the construction of the emergency brake valves for passenger and freight wagons are different, their operation is the same. In both the emergency brake cock and the emergency brake valve, the lever is vertical downwards in the closed position and horizontal in the open position.

19.1.6 Open-Close Switching Assembly

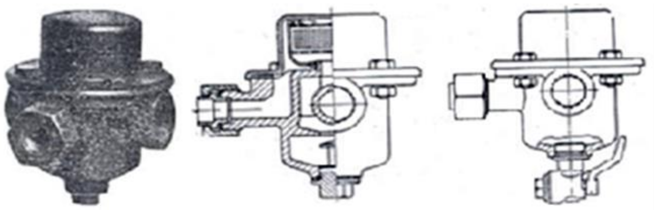
The brake can be opened or canceled either directly by means of the cancel cock on the triblivalve or indirectly by means of an open-close switching device. These are connected by a lever to a locking device and can be operated from either side of the wagon. The benefit of the on-off switching device is that it is easy to see from outside the wagon whether the compressed air brake is open or canceled. If the lever is perpendicular downwards, the brake is on. If the lever is parallel to the rail, the brake is canceled.

19.1.7 Auxiliary Air (import) Storage

Auxiliary air tanks, which are used together with the wagon brake, have no control function. These tanks store air for the brake cylinder. Their volume is subject to the size of the respective brake cylinders. In a complete operating brake with a normal piston system, the pressure of the air in the reservoirs is calculated to be slightly higher than that in the brake cylinder. This provides a kind of guarantee by compensating for leaks to compensate for the pressure drop in the brake cylinder.

19.1.8 Dust Bags

Dust bags prevent dust, dirt and moisture in the compressed air from reaching the sensitive brake parts. In this way, the sensitive brake parts are prevented from wearing out in a short time and the sensitivity is not impaired. If the brake parts are installed on a pipe, dust bags are installed in front of these parts as shown in the figure.



Centrifüge type dustcatcher

In principle, the air enters the upper connection pipe and hits the opposite side, allowing the impurities and water in the air to settle. The air cleaned in the fine mesh filter at the top continues its way through the pipe connection at the bottom. A plug is placed at the bottom for draining the accumulated water in the dust bag and a faucet can be placed instead of the plug if necessary. The dust bag should be installed as close as possible to the part to be protected and with the drain plug downwards. Air inlet and outlet should be in the direction of the arrow on the dust bag. The filters should be cleaned at regular intervals and the broken ones should be replaced.

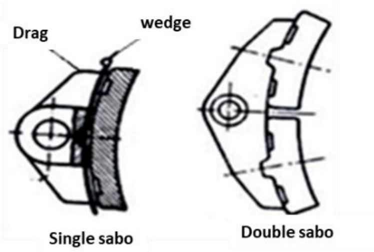
19.1.9 Brake Systems and Triblivalves

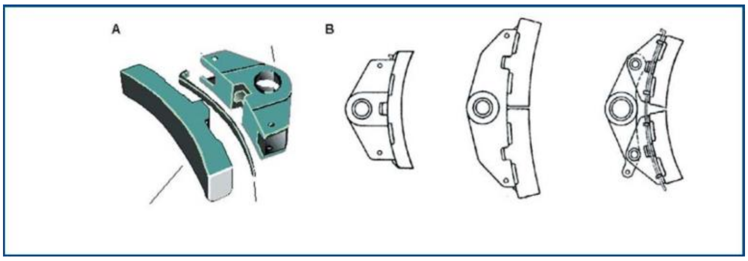
The multi-solution compressed air brake used in railway vehicles was first applied on German railways in 1917 as the Kunze-Knorr brake. Approximately after 1933, the Hildebrand-Knorr compressed air brake was used by Germany and other countries. This development was followed 20 years later by the Knorr compressed air brake with KE-Triblvalve. According to various types of brake systems used in railway vehicles, there are different types of brake rods and triblvalves. Oerlikon, Westinghouse and Hildebrand-Knorr (Hik) triblvalves used in some types of wagons in our organization did not find widespread use. On the other hand, the KE triblvalve has found widespread use due to its simplicity of use and its ability to fulfill the technical requirements demanded from the brake with a unit basic valve used in various types of vehicles such as motor trains, freight, passenger and express wagons.

19.1.10 Mechanical Parts

1. Sabos
2. Brake Rods
3. Hand brakes
4. Load Change Box and empty-full handles
5. Load-Passenger Switching device
6. Brake regulators

19.1.11 Sabos

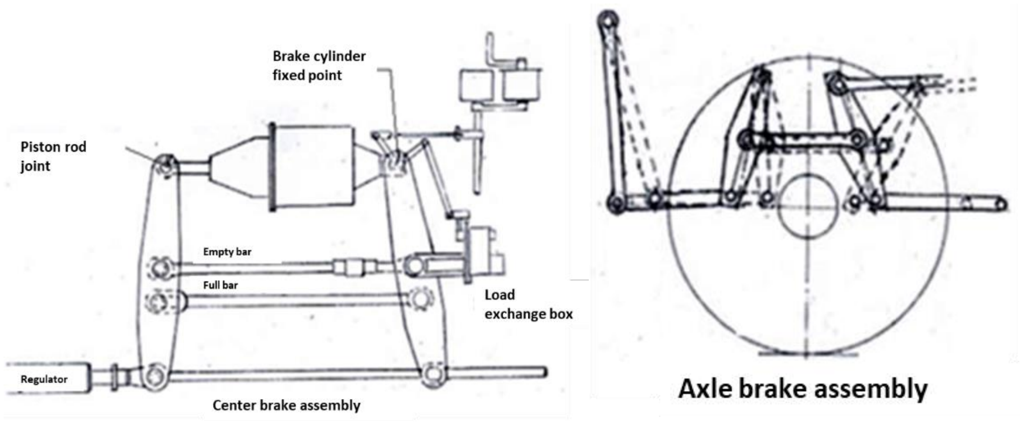




Sabos are made of cast iron or composite material according to special manufacturing specifications. It should be softer than the wheel material. The thickness is generally 60 mm. and 10 mm. is used until it is thick. The part to which the sabos used in one or two pieces are connected is called a sandal. It is also possible to connect more than one sabo to the same sandal. Sabo hardness is 180 brinel hardness. Recently, sabos made of composite materials are preferred due to their durability, lightness and ease of replacement.

19.1.12 Brake Rods

The brake rods transmit the mechanical force generated in the brake cylinder to the sabos, allowing them to press on the wheels. The compression of the force is generally magnified. The brake rods consist of two parts, the center brake assembly and the axle brake assembly. The center brake assembly consists of the brake cylinder lever, the fixed point lever and their cradle, connecting rod and parts, while the axle brake assembly consists of brake triangles, suspension rods, fixed point and brake lever bridge.



The arrangement of the brake rods is regulated by the manufacturing companies according to the brake systems and the regulators used. Some points should be taken into consideration in their arrangement. The rods should be placed in such a way that there should be no interruption in braking and unwinding, and all sabos should be separated from the wheels uniformly during unwinding. A properly constructed brake rod assembly should also be reinforced by means of a retraction silencer. When the brake is applied, the gap between the wheels and the sabos must first be compensated for, then the gaps caused by the flexing of the brake rods and the wear of the perno holes and perno holes. In other words, as the amount of wear increases, the brake cylinder piston travel also increases. As a result of the increase in piston travel, the air pressure in the brake cylinder will decrease and the brake effect will decrease. In order to avoid these drawbacks, the brake cylinder piston stroke must be kept constant, i.e. the wear and flexing must be compensated for. The easiest way to do this is to put adjustment holes on the rear brake rod. The distance between the adjustment holes should be 100-150 mm for passenger wagons and 100-200 mm for freight wagons. The adjustment holes should be located on both sides of the wagon at the beginning and end.

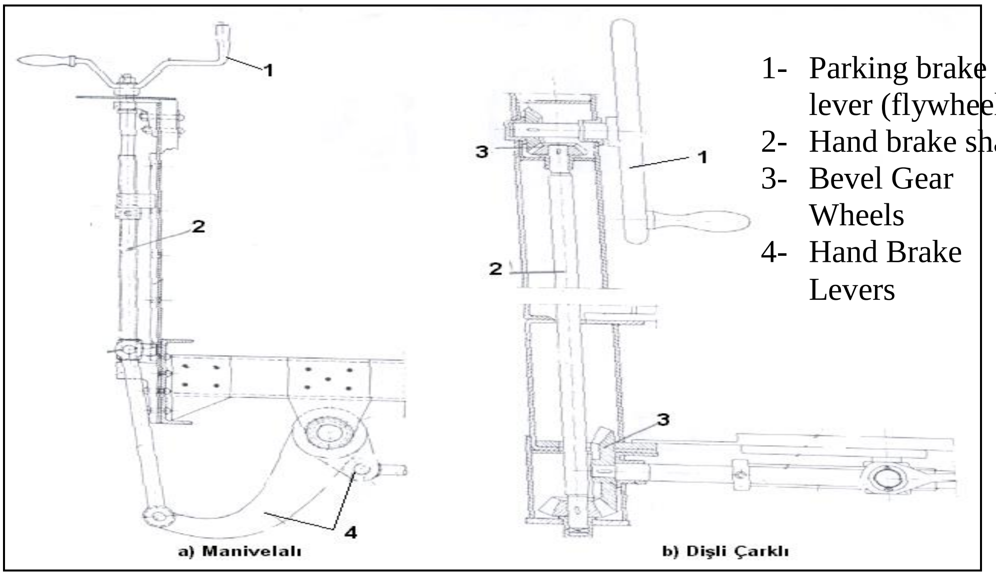
Regulators have been built to automatically compensate for wear and especially SAB type regulators have found application. However, due to the manufacturing of the wagons, it is sometimes not possible for the regulator to collect all the gaps to the end. For this reason, it is necessary to put adjustment holes on the rear train bar even in wagons with regulators.

19.1.13 Hand brakes

Hand brakes provide braking with hand force. The force that a person can provide is taken as 50 kg. Hand force is transmitted to the clogs in three ways;

- By pressing the lever,
- By rotating the ends connected to a gear,
- Hydraulically.

Of these, hand brakes made by pressing the lever and rotating the ends connected to a gear are the most commonly applied types. The hand brake of a vehicle must be strong enough to prevent the vehicle from moving spontaneously when the brake is squeezed while the vehicle is stopped on a steep slope. The hand brakes of the wagons given to the train car must be released. Otherwise, apletilikes will occur.



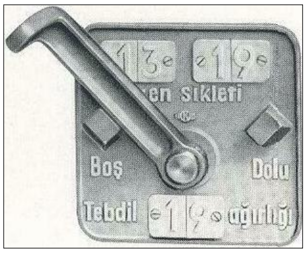
1- Parking brake lever (flywheel)
2- Hand brake shaft
3- Bevel Gear Wheels
4- Hand Brake Levers

19.1.14 Load Change Box and Empty-Full Handles

A heavy wagon requires a greater braking force to brake than a light wagon. Similarly, a loaded wagon needs to be braked more strongly than an empty wagon. For this purpose, either a second brake cylinder is used (as in KKG brakes) or the force transmission coefficient of the brake rods is increased. The latter method is used in the SAB load shifting device. It is generally used on freight cars equipped with Hik and KE brakes. For this purpose, the brake rods are connected via two rods, a full rod and an empty rod. The load shifting device is mounted on the empty rod. One end of the full rod is slotted. When the wagon is empty, i.e. when the load shifting lever is on the empty rod, the brake force is transmitted through the empty rod and when the wagon is full, it is transmitted through the loaded rod. Braking via the load change box is progressive load braking.

Operation: The figure shows the unloading and braking states in empty and loaded state. When the lever is idle, the load shifting device latch is closed. This latch is open when the lever is loaded. When the brake is applied in the loaded state, the neutral rod remains loose, whereas the loaded rod becomes tense and the force is transmitted through it. In the empty state the latch is closed. When the brake is applied, the pawl moves to the right by S_x and takes the brake force before the load rod is taut and the force is transmitted with a small transmission coefficient. When the load shifting lever should be empty and when it should be loaded is shown on a plate placed on both sides of the wagon.

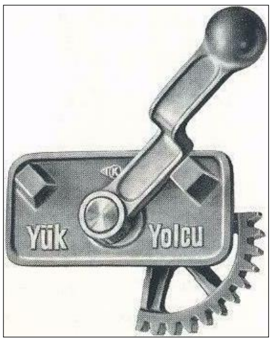
19.1.15 Empty-Full Load Change Lever



The changeover device has two states B=Empty and D=Full;

It can be controlled from both sides of the wagon. By turning the lever, it is connected to a load change box in the case of mechanical braking or to a relay valve or change cock in the pneumatic system, which can be adjusted with compressed air. The brake weight plate of a braked freight wagon has 3 fixed numbers , two of which are at the top and indicate the brake weight. The lower number shows the replacement weight, i.e. the tare of the wagon and a part of the load. If the sum of the wagon tare and the specific load is less than the replacement weight, the lever is turned to "Empty". If the sum of the wagon's tare and the cargo placed inside is equal to or greater than the replacement weight, then the lever is turned to "Full". If the empty-full lever is set incorrectly, i.e. if the wagon is full and the lever is empty, the brake will be insufficient and this will cause the train to run away, if the wagon is empty and the lever is full, the brake effect will be too much and this will lead to a breakdown. Therefore, the empty-full lever must be adjusted correctly.

19.1.16 Load-Passenger (G-P) Switching Arms



This switching device is installed on passenger wagons that can also operate on freight floors. The G-P lever has two states, G=Freight car and P=Passenger car, operated from both sides of the wagon.

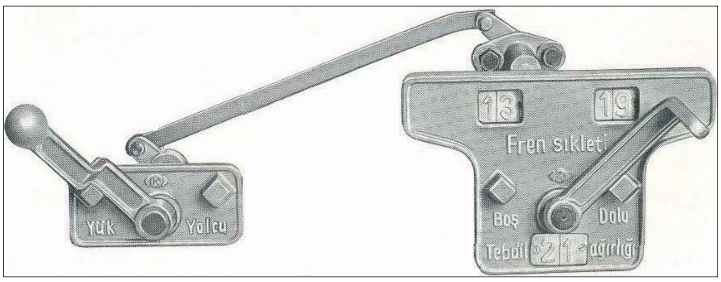
By turning the lever, it is possible to switch either to the freight train brake with slow brake effect or to the passenger train brake with fast brake effect.

Whether or not a passenger car is equipped with this changeover device depends on the needs of the railway undertaking.

This device, which adjusts the braking and release time with the brake cylinder contact via the triblivalve, is connected to a lever on the side of the wagon with a rod. It adjusts the braking and release times for freight and passenger cars as they are different.

	Braking	Solving
On freight trains(G):	18-30 seconds	45-60 seconds
On passenger trains (P):	3-5 seconds	15-20 seconds

19.1.17 Connection of the Empty-Full Load Switching Assembly with the Cargo-Passenger Cargo Switching Assembly (B-D/G-P Switching Assembly)



In fast-moving freight wagons with load-passenger floor brakes, in addition to the Empty-Full (B-D) switching device, there is also a G-P switching device. The B-D switching device has a numbered slider on the brake weight plate and is connected to and controlled from the G-P switching device. In the G state, the brake weights for the freight train operation and in the P state, the brake weights for the passenger train operation with a larger value are displayed in the brake weight plate windows. The change weights for G and P are the same.

19.1.18 Brake Regulators

Sabo and bandages, and in the case of disc types, disc and brake pads, wear out due to friction on the contact surfaces during braking. Likewise, over time, the gaps in the perforations and holes in the brake levers become larger. These abrasions also increase due to the precedent of movement in the brake levers and thus cause an undesirable prolongation of the piston stroke. For this reason, it is necessary to adjust the brake rods from time to time. For this purpose, it is useful to use brake regulators that can self-adjust to changes in piston speed that occur during operation. This eliminates the need for manual adjustment of the brake rods. Normally, the brake regulator is mounted between the center and axle brake rods instead of the main brake traction rod.

19.1.19 Wagons with Automatic Full and Empty Wagons

It is seen that the freight wagons produced in recent years are produced with automatic load-unloading devices. The advantages of the automatic full-unloading system are as follows:

- Eliminates human error as there is no mechanical turning lever.
- It provides multi-stage load braking instead of 2-stage load braking defined as full and empty like mechanically equipped wagons.
- It eliminates the load dependency of the brake, as it automatically adjusts the brake power needed due to increasing load to maintain a constant braking ratio.

In order to explain the operation of the system, the "KE-GP-A-2X16" braking system installed on bogie container wagons is introduced below as an example.

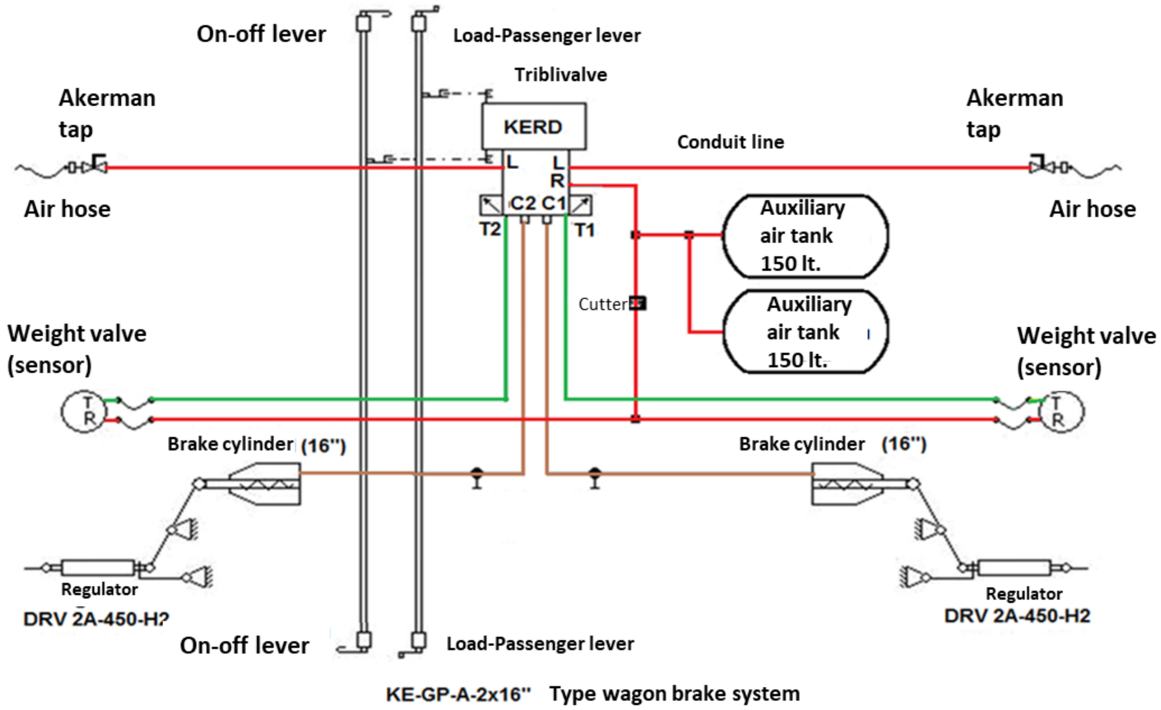


Figure 19.2 Schematic of KE-GP-A-2X16" brake system mounted on bogie container wagons

1) In the brake system, 2 brake regulators of type DRV2A-450-H2, 2 auxiliary air tanks with150 litre total300 litre capacity, triblivalves of type KERd- KSLn, 2 brake cylinders with16" diameter, 1 for each bogie and 1 weight valve (sensor) for each bogie were used.

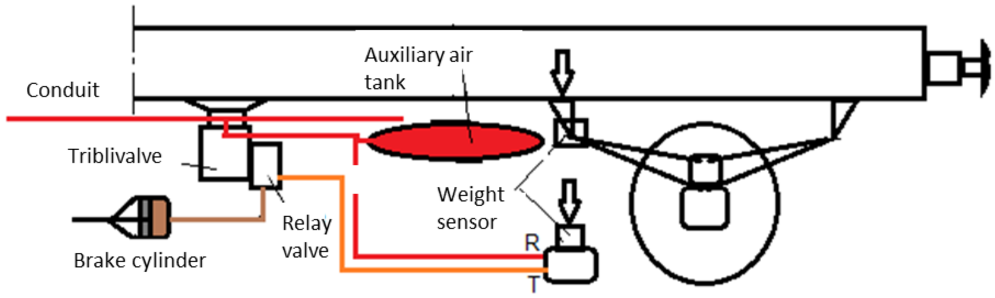


Figure 19.3 Weight valve (sensor)

2) The sensors are mounted on the coil sustains that provide the bogie suspension. It is fed through the pipe to the auxiliary tanks. When the wagon is empty, it passes approximately 1.00 bar air . As the load is placed in the wagon, the passage pressure increases and passes 3.65 bar air when fully loaded.

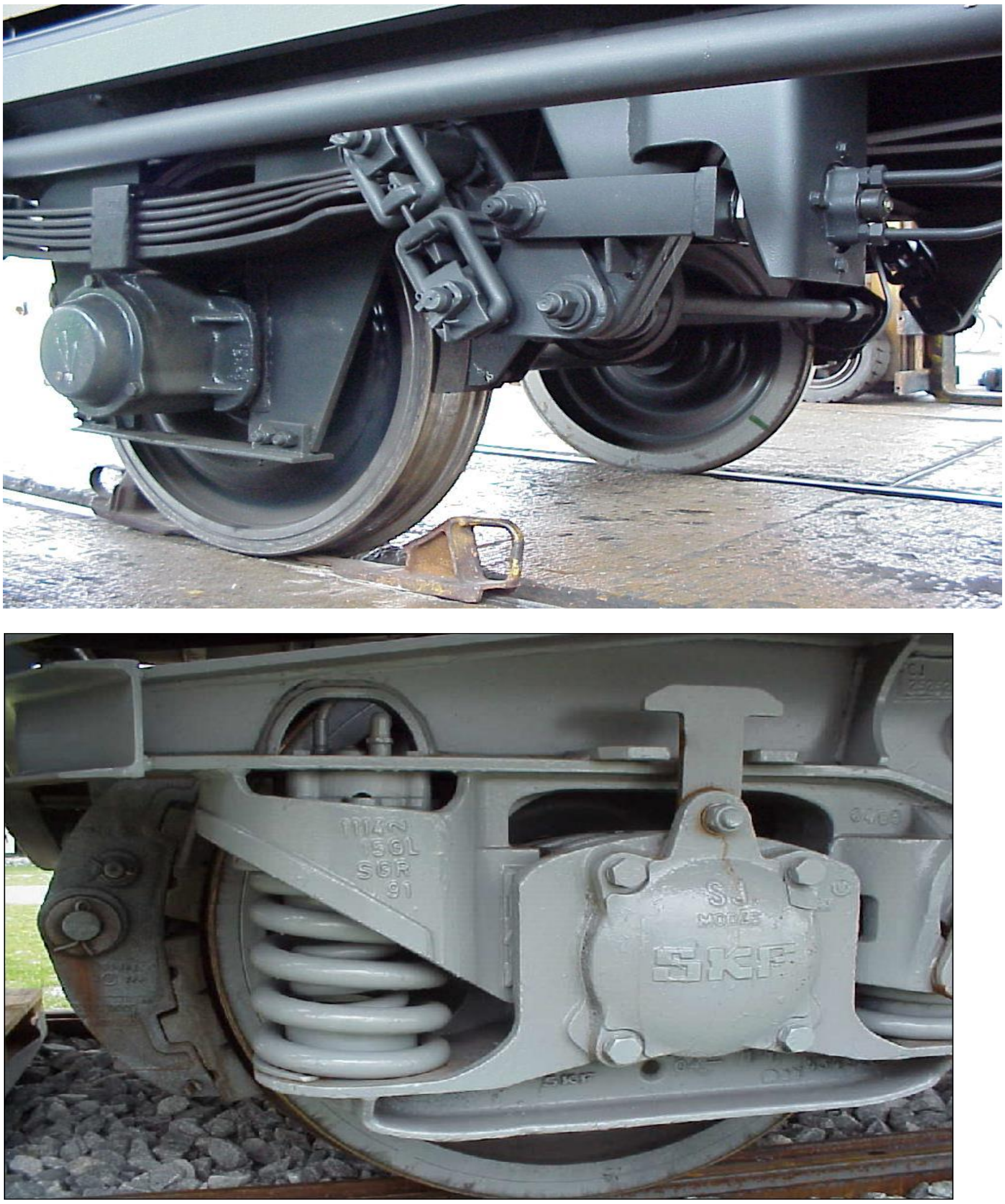


Figure 19.4 Weight valves

3) According to the sensor passage pressure, the load relay valves mounted on the triblivalve change the maximum brake cylinder pressure at full brake. If we give an example from the table; if a full brake is applied with a total wagon weight of 70 tons with its load inside, a brake cylinder pressure of 3.52 bar occurs. If a progressive brake is applied, the brake cylinder pressure is lower in proportion to the reduction in the conduit.

4) As the wagon load increases, the sensor transition pressure increases, as the sensor transition pressure increases, the maximum brake cylinder pressure for full brake increases. In this case, if a full brake is applied, the brake weight, i.e. the brake force, increases as the brake cylinder pressure increases. (The opposite processes occur as the load decreases)

5) Since the brake weight increases as the wagon load increases, the braking ratio does not change much.

6) Max. brake weight value is written on the wagon. For the sample wagon, this value is 72 tons.

7) Brake weight is the sum of the load and the tare, provided that it is not less than the tare of the wagon and does not exceed the maximum brake weight value written on it. In other words, it is taken at 100% braking rate provided that it does not exceed the maximum value.

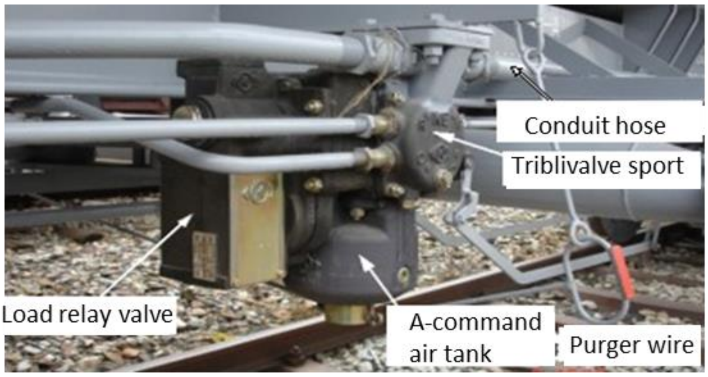


Figure 19.5 Triblivalve and mounted load relay valve

Figure 19.6 Triblivalve and mounted load relay valve

The following examples explain the inscriptions on this type of wagons and their meanings.

Figure 19.7 Sample writings on the wagon

MH : Brake system company nickname (MZT HEPOS)

GP : Brake modes.

A : Automatically adjusts brake power according to the load (with automatic full-empty device)

MAX : 29 t : Brake weight at full load and full brake

Figure 19.8 Sample writings on the wagon

KE : Brake system company nickname

GP : Brake modes

A : Automatically adjusts brake power according to the load (with automatic empty-load device)

MAX 58 t : Brake weight at full load and full brake

19.2 Y25 Bogie with Integrated Compact Brake System

Integrated Bogie Brake System

CFCB (Knorr) / IBB10 (Wabtec) /BFCB (Faiveley)

Figure 19.9 BFCB Brake System

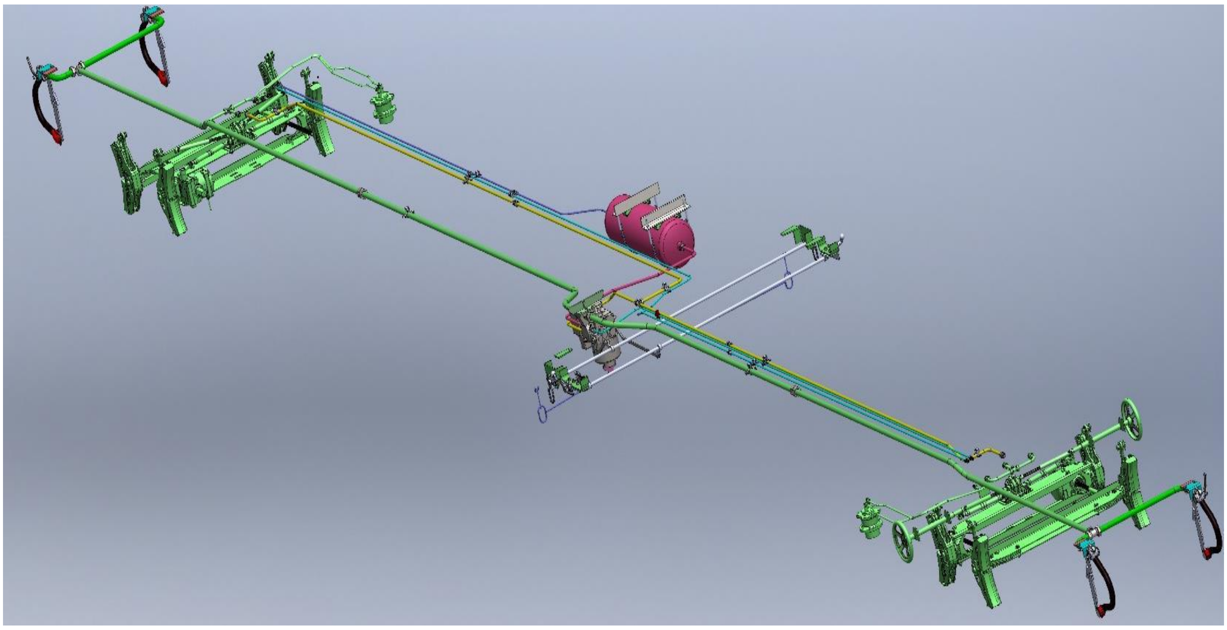


Figure 19.10 CFCB Light -Compact Freight Car Brake Light

Comparison of Brake System Hardware in Bogies

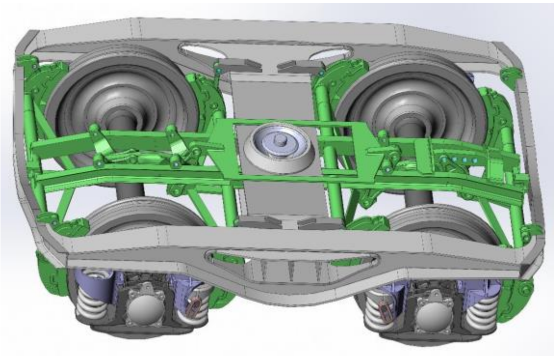


Figure 19.11 Conventional Y 25 Bogie

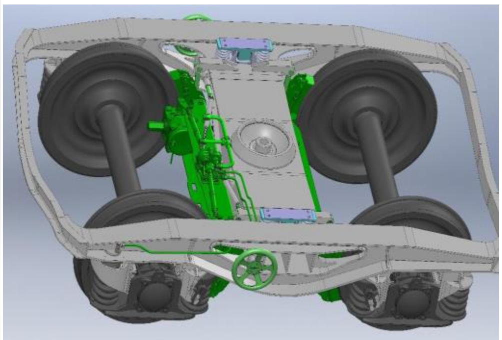


Figure 19.12 BFCBY 25 Bogie

The parts shown in green belong to the brake system.

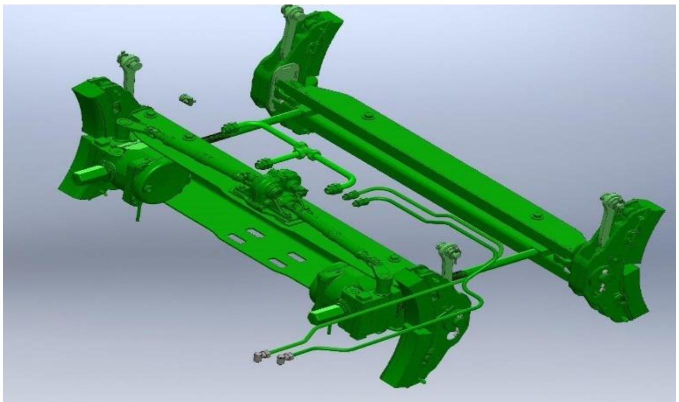
Brake System Specifications

KompactBrake system

Brake cylinder,

Brake regulator

There are no muselles



Compact Brake System Features

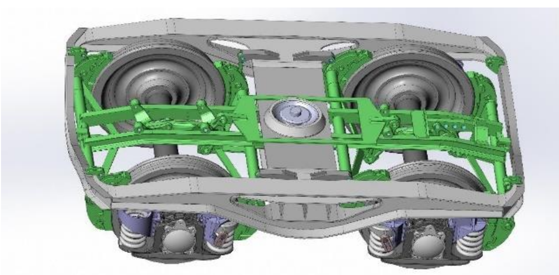
-Speed of 120 km/h at idle

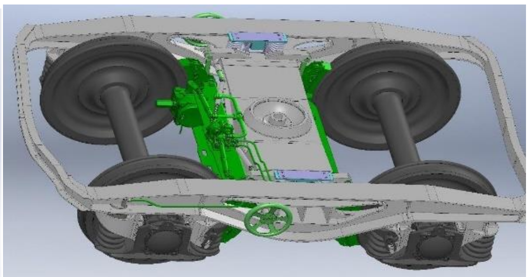
-100 km/h speed in hail

-A maximum load of 18 tons axle pressure can be carried at 120 km/h

-Sabolar TSI approved Cosid810/Jurid816 brand Bgu/Bg'K' type

Compact brake system Advantage-Lightweight



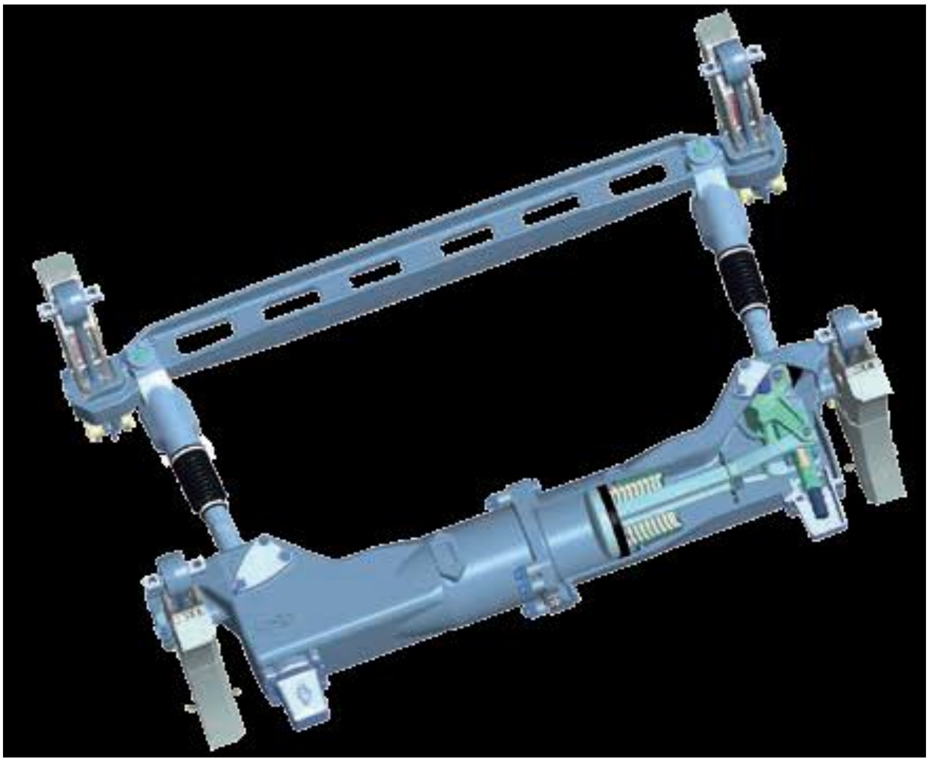


Conventional Bogie	**BFCB Bogie**
Weight	**Weight**
4777 kg	4228 kg (with hand brake)
	4190 kg (without hand brake)

-The 500 Kg reduction comes from the omission of the chassis-mounted brake cylinder, brake regulator and the supports that connect them to the chassis.

-Compared to conventional braking systems, the BFCB Brake system *provides approximately 1,600kg lighter weight per railcar*.

-Lower material and labor costs in production due to fewer parts



20. BRAKE FAILURES

20.1 Wagon Brake Malfunctions

Brake failures that are likely to occur in wagons can be grouped into two main groups;

a. Failures caused by a deficiency in the brake assembly, such as breakage, excessive wear, loosening of fittings, debris coming from the brake air pipes or some parts not working due to frost
b. Malfunctions due to deficiencies in maintenance and preparation of brakes;
    - Incorrect connection of hoses: TVS 2000 Wagons have 4 connection hoses at each end. These are in series 2 by 2. Door line hoses and brake hoses.

Note: Here, there is 5 bar pressure coming from the engineer valve in the brake conduit line and 8-10 bar pressure coming from the main air tank of the machine in the door line.

- Air connection faucet handles are in the wrong condition
- Handbrake stuck
- Emergency brake faucets remain open, lack of sufficient pressure in the conduit
- The blinds stay open.

Failures due to the deficiencies mentioned in "b" can be easily remedied by following the instructions.

Many malfunctions are prevented by hanging the unused air hoses on the hanger, cleaning them by supplying air to the condenser, and straightening the bent purge wires.

Air hoses that are not hung in their places fail during maneuvering services and during navigation due to vibrations. Dust, dirt and snow accumulate here and pass to the conduit and from there to the brake management parts, causing rapid wear and clogging of the valves. Harnesses or similar parts that are not hung in their places also cause brake hoses to malfunction.

20.2 Procedure to be Considered in Malfunctions

In faults, the most difficult possibilities are usually considered instead of the simplest ones. Finding brake faults depends on thinking and taking your time. Before starting to look for a malfunction, it is checked whether there is air in the system and whether the faucet handles are in the correct position. A 150-axle train needs 10-15 minutes to fill up.

For this reason, a sufficient time should be allowed for the length of the train and then the braking should be practiced. Sufficient time should also be left for braking and releasing. "**Apply Brake**", "**Release Brake**" signals to be given to the engineer should not be hurried and should not be followed immediately by pulling the purger.

20.3 Finding the Cause of Failure

It is a waste of time to try to remedy a malfunction before the cause of the malfunction is known. In many cases, the fault may not be in the wagon that is thought to be faulty, but in another wagon. Because the fault may also be in many wagons. For this reason, it is checked whether the malfunction is in one wagon or in several wagons, whether it occurs during braking or uncoupling, whether the brake cylinders and pads are tight or not.

First, the condition of the red and green plates on the brake indicator gauge is checked during braking and release. If there is an abnormality, it is checked whether the brake discs are tightened by the pads. The indicator may also be faulty.

20.4 Faults Occurring in a Wagon

If there is a malfunction in one wagon, then there is no malfunction in the conduit and air hoses. Because such a malfunction affects several wagons.

The cause of the malfunction is in the wagon brake equipment. It may be in the triblivalve, air tanks, brake cylinder, brake cylinder canceling device, purge. If the pressure gauge in the wagon reads 3.6 bar pressure, the fault is in the brake system on the bogie, if not, it is in the brake system on the wagon. If the malfunction is due to a deficiency, a long time is needed for its elimination. If repair is not possible, the brake must be canceled. However, this must be taken into account in the brake calculation. If the brake failure cannot be repaired, the brake must be canceled and must be labeled. The brake of the wagon whose brake is canceled must be loosened by pulling the purge.

20.4.1 If the brake of a wagon does not hold or releases spontaneously;

After brake experience, if a wagon's indicator is always green (i.e. the pads are not squeezing the disc), it is decided whether the fault is the indicator itself or whether the pads are squeezing the disc.

The pressure gauge on the hand brake cabinet shows the brake cylinder pressure. This shows whether the fault is on the bogie or on the brake actuators on the wagon.

If the pressure gauge shows 3-3.8 bar pressure and the brake does not work, the fault may be in the connecting hoses, anti-skid valves or brake cylinders

If the pressure gauge does not show 3-3.8 bar, the fault may be in the triblivalve, tank, cancel cock or purge.

If the brake still does not hold and releases by itself as a result of the controls, it means that the fault is in this wagon. Even if the malfunction is eliminated, the brake is left in working condition in the operating conditions and it is checked whether the brake of this wagon works or not in the subsequent brake tests during the cruise. Because sometimes such malfunctions may occur due to a blockage and jamming.

As long as the brake of this wagon does not work, it is not included in the brake calculation of the train.

20.4.2 If a Wagon's Brake Won't Release;

If the brake of a wagon does not release even though it releases the brake in the wagons before and after it;

1. First check that the parking brake is tightened.
2. If the handbrake is released, we try to separate the sabo or pad by applying force to the cylinder retaliation levers. If it does not release, the engineer is notified.
    - The engineer gives a very short wave of compressed air (he must load the conduit over 5 atm.).
    - If the brake of the wagon still does not release, the purge is pulled slightly.
    - If it still does not solve the problem, the brake experience is repeated.
    - If the brake fails to release again, the brake is canceled and the wagon is deaerated by pulling the purge until no air comes out.
    - If the wagon brake cannot be loosened by pulling the purger, a master who understands brake work is notified if time permits. Otherwise, this wagon is removed from the train.

20.4.3 Failure of Several Wagons

If several wagons malfunction during the brake test, these malfunctions cannot be eliminated by canceling the brake of any wagon. In such cases, the cause of the failure is generally in the train. If it is possible to carry out the test with a fixed compressed air system, it should be tried separately by supplying air from both sides of the test train. First, the first wagon with faulty brakes, the wagon whose brakes are working properly, and the train car are examined.

Because it is possible that there is a blockage in the conduit after the air connection to the triblivalve of the wagon whose brake is working normally. It is checked whether the air connection taps between these two wagons are open and whether they pass the air properly. If no fault is found, it is determined whether the fault occurred during braking or unwinding.

It must be ensured that all brakes are released before the experiment.

If the brakes of some wagons do not release before the brake test, the situation is reported to the engineer. The engineer checks whether the air pressure is full or not by looking at the manometers (by putting the engineer's faucet lever to the stop position).

Again, the engineer checks whether there is an air leakage or not while the tap is in the suspended state. Air leakage is eliminated. If it is not possible, the wagon is removed from the train. If the brakes of some wagons still do not release, it should be suspected that there is too much air leakage into the conduit. In this case, the brakes are applied by lowering the conduit to 4,5 atm. and the wagon purifiers are pulled. If no result is obtained from this, it is judged that there is a blockage in the conduit and action is taken as described below.

In order to find out whether there is a blockage in the conduit, the air connection hoses between the wagon whose brakes are working properly and the wagon whose brakes are not released are opened for a short time and especially by paying close attention to the sound, it is determined from which side the air outlet is strong. On the side where the air outlet is weak, it means that there is a blockage in the conduit. Generally, the blockage is in one of these two wagons. The wagon with the blockage is removed from the train. If the air flow from both hoses is equal, the malfunction is in the air couplings. In this case, the air taps are closed and the air hoses are replaced. Brake experience should be done and it should be determined that the malfunction is eliminated. If the malfunction persists, it is understood that there is a cause of obstruction in the first wagon in motion and that it blocks the road with the effect of the compressed air coming from the back to the front during braking. In this case, a test should be made by opening the opposite side air hose and paying attention to the air outlet.

If several wagons do not pass the brake, the wagons in the front pass the brake and the wagons in the back do not pass the brake because the air flow from the back to the front in the conduit is not uniform. The inspection is carried out on the first wagons in the braking and non-braking sections.

If the brakes of several wagons do not release, this may be caused by non-uniform air flow from front to rear, high pressure in the air tanks, excessive air leaks. These issues should be checked in order.

During these inspections, the engineer must always be present on the machine and ensure that there is sufficient air in the conduit.

20.4.4 ***Air Leaks***

One of the most important causes of brake failures is air leaks. Air leaks are of two types;

- One is leaks from the condenser, air tanks, air tanks, air hoses, brake cylinders, which are usually audible as a sound.
- The other is the generally inaudible air leakage from the high-pressure compartments to the low-pressure compartments as a result of a defect in the triblivalve.

The first type of leakage should not exceed a certain value in a train. If this amount of leakage exceeds (0,5 atm in freight train, 0,3 atm in passenger train) in one minute in a 100 axle train, the leaking places should be found and the malfunction should be eliminated. It is appropriate to use skilled personnel in the elimination of leaks. Leaks in the triblivalves cause spontaneous braking or unbraking. Such faults can also be eliminated over time with various braking and unwinding.

The second type of air leakage is usually temporarily solved by closing the cancel lever. However, the brake of this wagon must be released and deducted from the brake account.

21. BRAKE EXPERIENCE UNDER OPERATING CONDITIONS

Brake tests are carried out to determine whether train brakes are suitable for use.

a. That the compressed air flows normally from the conduit to the end of the train, and that there are no air leaks in the conduit, air hoses, air hoses and couplings, air connection taps, triblivalves, tanks and brake cylinders,
b. After a brake by the locomotive, the wheels of all braked wagons are checked to see if the pads are tightening the discs. (We can also see this on the indicator)

Brake trials are done in two ways;

1. Full train experience: This is to check that all the brakes of the train are working.
2. Simple brake test: This checks whether the brakes of the wagons added to the train and the last wagon of the train are working.

21.1 Full Brake Experience

A full brake test is carried out in the following cases;

- At the departure and arrival stations where trains are organized,
- Border stations,
- At ramp-head stations,
- The engineer suspected that the braking effect was weak,
- Full brake experience is performed when required by the company.

21.1.1 How it is done:

The engineer, train conductor and wagon technician perform the full braking experience together.

a. Before starting the full brake test, the train conductor and the wagon technician check that the air hoses are connected properly, the acerman taps are in the open position, the full-empty levers are arranged in accordance with the tonnage of the cargo, the triblivalf open-closed levers are arranged in the open position in wagons without brake failure. After completing the deficiencies, he tells the engineer to fill the air. The engineer brings the faucet lever to the filling and road position and when these works are done, the brake experience is started.

b. After the train conductor and wagon technician learn from the engineer that the knee is completely filled with air, they check whether all brakes are loose, and if there is a wagon with a loose brake, the reason is investigated. If the fault cannot be eliminated, the brake is canceled and the air is completely evacuated by pulling the purge. The label "**Brake is broken**" is affixed.
c. After all brakes are found to be in a loose condition, the train conductor gives the signal "**Brake**" from the head of the train. The engineer responds to this signal with the engine whistle and brakes by releasing 0,5 atmosphere of air from the conduit.
d. The train conductor and the wagon technician then check whether all brakes are tightened from the beginning to the end of the train. If a brake fails, the cause is investigated and the brake is applied again if necessary. If the fault cannot be eliminated, the brake is canceled and the brake is labeled as defective.
e. After the train conductor sees that the last wagon of the sequence has tightened the brakes, he gives the signal "**Loosen Brakes**". The engineer responds with the engine whistle and loosens the brakes. The train conductor and the wagon technician go through the whole sequence and check whether all the brakes are loose or not.
f. Meanwhile, the engineer checks the train for air leaks.
g. Brakes must be loosened by the engineer. It is dangerous and forbidden to try to loosen a brake that cannot be loosened by the engineer's faucet with a purge instead of canceling it and thus preventing the malfunction from being seen.
h. When it is understood that the brakes of all the wagons in the sequence are loose, the experiment is considered to be over and the engineer is given the "**Brakes in Order Signal**"

21.2 Simple Brake Experience

a. When one or more carriages are removed or added to the train,
b. In case the locomotive pulling the train is replaced or out of service for a short period of time (such as catenary disconnection in electric locomotives, pantograph remaining in the down position for a long time).
c. Undoing and reinstalling the brake hoses for any reason and opening and closing the akerman taps,
d. After repairing a brake fault, simple brake practice is carried out.

The simple brake test is similar to the full brake test. Only in the simple brake test, it is checked whether the wagon with the last air brake and the wagon brakes added to the train are working properly. The course of action is as described in the full brake test.

21.3 Considerations in Brake Experiments

1. It is forbidden for anyone other than the train conductor to give signals during brake tests and to use signals other than those specified in the signal instructions. The engineer shall not accept and repeat the signals given contrary to these.
2. From the beginning to the end of the experience, the engineer directs all his/her attention to the signals given by the train conductor. The train conductor shall not leave the train for any other work, nor shall he be assigned to any other work by his superiors and shall not interfere with his work. Those who are in charge of the

inspection duty shall apply only to the train conductor at this time and report the defects and irregularities they will see.

3. The train conductor writes on the traffic chart that the brakes are in order and the train conductor, the engineer and the wagon technician sign together for full brake tests. The officer in charge at the end of the train is in charge of simple brake tests. He does not sign the traffic chart. However, he is held responsible for the "**Brakes are in order"** signal he will give at the end of the train, if necessary.
4. During the brake tests, the wagon technicians are under the command of the train conductor and ensure that the damages and defects to be seen during the brake tests are corrected.
5. In both full and simple brake tests, the engineer shall not move the train until he is given the "brakes are in order" signal and the fact that the brakes are in order is written on the traffic chart and signed by him.
6. At stations with fixed brake installations, if the brake inspection of passenger train trains is carried out shortly before the departure of the train and no changes are made to the train until the departure, this inspection is also considered as a brake test, but a simple brake test should also be carried out after the machine is connected to the train.

22. Source

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