Programa de Actividades Complementarias a la Educación

”Madrid, un libro abierto”

2024

Museo del Ferrocarril de Madrid

Madrid Railway Museum

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políticas sociales, familia e igualdad | MADRID

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Contenido

1. PRESENTATION OF ACTIVITY

We will delve into the fascinating world of the railroads by visiting the Madrid Railway Museum, located in the historic Delicias Station. This 19th century building evokes past times of top hats, long dresses, parasols, and workers busily unloading goods from trains. It is not surprising that it has been the scene of films and commercials, such as the famous “Doctor Zhivago” and series such as “Cuéntame cómo pasó” and “El tiempo entre costuras”.

The inauguration of the station on March 30, 1880 was a great event that was attended by King Alfonso XII as well as members of the government, Madrid authorities and some of the most distinguished people of the time. The station was originally projected by the company C.R.B. (Ciudad Real and Badajoz) that ended up being absorbed soon after by the great railway company M.Z.A. (Madrid, Zaragoza and Alicante). While the M.Z.A. was building the Atocha station, it was decided to sell this place to the recently created company M.C.P. (Madrid, Cáceres and Portugal). However, while the station was being built both companies shared space until 1893.

It was during this period that a large number of works were carried out, enabling the building designated for passengers to include new waiting rooms for first, second, and third-class travelers. However, this station did not only serve passengers; due to its privileged location and connections, it also began to receive a large amount of goods.

More docks had to be built to handle the arrival of these goods, and a large number of tracks were added. Additionally, the facilities were expanded to store coal, scales, and other commercial dependencies. This made the station one of the main ones in the Spanish capital. In fact, the older generations will remember this station as one of those featured in the first versions of the board game "Monopoly" as one of the stations for sale.

Image 1: Exterior of the station

The next company to take over the station was known as the Oeste (National Company of the West of Spain). This company launched an ambitious renovation plan to adapt it to the new uses it was to be given. With the increase in traffic, it was necessary to build a roundhouse for locomotive exchange with a capacity for 24 engines, renovate the station lobby, improve the access road, and construct a central platform.

With the arrival of RENFE in 1941, the station underwent further renovations, especially in the passenger area, and some of the station offices were expanded. Considering that the number of motor vehicles was increasing and being used for the transportation of goods, a large truck garage was built. Pavilions were also constructed to repair passenger cars, inspect vehicles, and a barracks for the 7th Railway Unit. In 1967, the station lost its main garden, located in front of the entrance, to accommodate a modern RENFE Computing Center, which is still in use today.

Many of the previously mentioned structures, such as the large roundhouse, disappeared when the station closed to service. This station ceased operations in 1969, after almost a century of activity.

Its closure threatened its disappearance, but 1980 marked the year of the revitalization of this station. An agreement was reached for RENFE and the Ministry of Culture to establish the Railway Museum and the National Museum of Science and Technology in this space.

One of the most notable and appreciated works by the visitors of this museum was the closure of the south part of the main building, which prevents the cold and rain from entering during the winter. This allows the trains to be better preserved and the station to adapt to its new use as a museum.

Finally, on December 19, 1984, the museum was officially inaugurated as the National Railway Museum of Madrid at Delicias Station, now known as the Railway Museum of Madrid. For this purpose, the collection from the former railway museum, located in the Palacio de Fernán Núñez and managed by RENFE, was moved. Currently, the organization managing this museum is the Spanish Railways Foundation (FFE), established in 1985.

In 2009, the Railway Museum of Madrid was included in the Network of Museums of Spain, affiliated with the Ministry of Transport, Mobility, and Urban Agenda.

2. EDUCATIONAL OBJECTIVES OF THE VISIT

- **GENERAL OBJECTIVES**

1. To understand the evolution of the railway from its origins to the 21st century, with special mention of the Industrial Revolution and the differences between 19th-century, 20th-century, and current trains.
2. To know, enjoy, and appreciate the historical heritage of Delicias Station and contribute to its necessary conservation as a source of knowledge, wealth, and legacy for future generations.
3. To promote interdisciplinary work, integrating areas such as geography, mathematics, literature, and art.
4. To learn outside the classroom in an interactive and participatory manner, understanding the history encompassed by Delicias Station, the railways it houses, and the information it provides about the past of the railway world.

- **SPECIFIC OBJECTIVES**

1. To know the historical atmosphere of the 19th century and Madrid of that time, especially at the political and social levels.
2. To study the fundamental events that led to the construction of Delicias Station and the reasons that motivated the construction of railways in Spain, as well as the different train models.
3. To understand the operation and importance of the train in its entirety, appreciating it as a technological marvel and a testament to past and future eras.
4. To learn the railway language adapted to different courses and acquire specific terminology, using it with precision and knowledge.
5. To value the station-museum in its spatial and temporal dimensions, as an object of History.
6. To analyze the characteristics of Spanish society and its relationship with the railway, and how life changed in large cities and the countryside.
7. To know the evolution of the railway through the models exhibited in the museum's collection.
8. To appreciate the importance of the train as a means of transport and a driving force of society.
9. To be aware of technological evolution through the trains.
10. To promote environmental awareness and emphasize the impact of the carbon footprint left by means of transport.
11. To know the types of fuel or energy used in different locomotives/trains.

2.1 METHODOLOGY

The methodology will be actively participatory, as follows:

- Ensure that students learn practical, useful, and concrete knowledge applicable to their daily and working lives.
- Foster critical and reflective thinking about the world around them and the knowledge they are acquiring.
- Reward curiosity by encouraging visitors to ask questions.
- Encourage visitors to develop skills in information searching and analysis and its practical application.
- Promote autonomy and individual responsibility, as well as teamwork and group awareness during the museum visit.
- Make the visit dynamic and participatory, allowing visitors to discover a unique and singular place in a playful manner.
- Organize the museum visit so that it allows students to express themselves and find elements within the museum that are present in their daily lives. Additionally, they will be encouraged to reflect and ask questions about the machinery on display, thus facilitating the resolution of their doubts. This approach will promote a respectful and polite presentation of their opinions and questions.
- Adapt the visit to the students' level, increasing the amount of data and exposure depending on the level, ensuring understanding and interest.

3. PREVIOUS WORK IN THE CLASSROOM

Teachers should prepare the museum visit in the classroom, treating this activity as a point of convergence between the museum and the students, with the teachers serving as the connecting link.

It should not be approached as an isolated extracurricular activity but rather should include some preliminary work in the classroom so that students become familiar with the museum and the topics to be developed during the visit. These activities should be structured around the curricular objectives and content present in the curriculum of the corresponding course, taking on importance within the course and subject planning. In this way, the visit will be relevant to the students and increase their interest.

Furthermore, it is important to note that the preparatory work for the visit should go further. In this sense, the importance of the work during and after the visit should be highlighted, as these are as important as the preparatory work.

- Recommendations for teachers prior to the visit:
  - Contact the museum and attend the visit presentation by the city council.
  - If necessary, seek advice from the Education Area regarding educational materials or activities that could be carried out to prepare for the visit.
  - Try to coincide the visit with the content being taught in the classroom at that time.
- Recommendations for teachers during the visit:
  - During the visits, the teacher can provide additional information to complement the guide's explanations and even place the students in the context of the explanation.
  - It is important for the teacher to keep an eye on the students, maintaining order and manners in the museum.
- Recommendations for teachers after the visit:
  - To ensure that the visit is not just a mere excursion or school outing, it is recommended that teachers carry out activities in the classroom that reinforce or recall the knowledge acquired during the visit, emphasizing the value of this knowledge.

4. ACTIVITY: DIRECTIONS, TRANSPORT STOPS, AND ACCESSIBILITY

- **Address:**
  - Railway Museum of Madrid, located at Paseo de las Delicias, 61, 28045 Madrid.
- **Public Transport Stops:**
  - **Cercanías (Commuter Train):**
    The nearest Cercanías stop is Delicias, with connections to lines C1 and C10.
  - **Metro:**
    The nearest Metro stop is Delicias, with a connection to line 3 (yellow).
  - **EMT:**

    The nearest EMT bus stop is 5036 DELICIAS-CÁCERES, located at Pº de las Delicias, 69, at the corner with C/Tomás Bretón. The lines that pass through this stop are: 8, 19, 45, 47, 59, 85, 86, and 247.

- **Location:**

  Location on Google Maps: Click here to access the Museum's location

- **Parking:**

  Buses can stop to drop off students on Calle del Párroco Eusebio Cuenca Street address (although it may seem like a restricted access area).

- **Accessibility:**

  The visit can be adapted for students with motor disabilities, although there are certain places that are not accessible. Depending on the needs, the route will be modified.

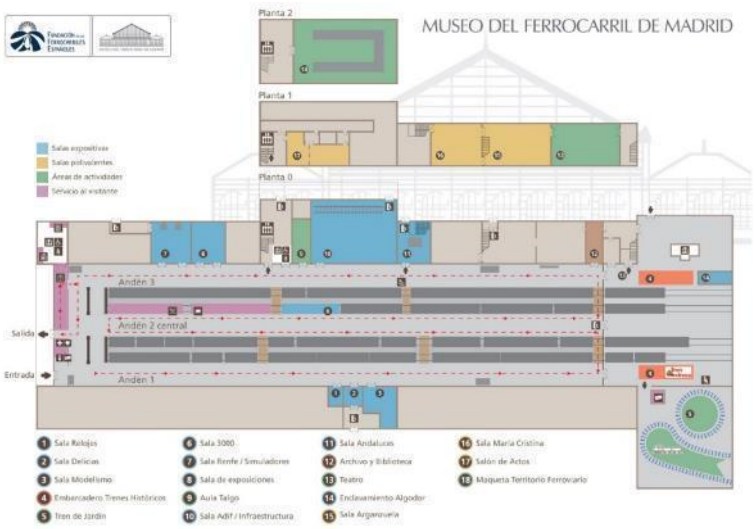


Image 2: Map of the Railway Museum

5. RULES OF CONDUCT AND BEHAVIOR OF STUDENTS DURING THE ACTIVITY

- Teachers must supervise their students at all times, ensuring good behavior and manners to facilitate the proper development of the visit.
- Teachers must communicate in advance if any adaptations are needed during the visit and specify the related needs.
- Silence must be maintained to allow guides to conduct their tours without disturbances between groups, and students should raise their hands to ask questions.
- It is forbidden to go down to the tracks.
- Trains on display can only be touched with permission to avoid accidents such as bumps, stains, cuts, etc.
- At the end of the visit, a QR code will be shown to complete a survey about the activity.
- Punctuality is requested.

6. STOPS / POINTS OF THE VISIT

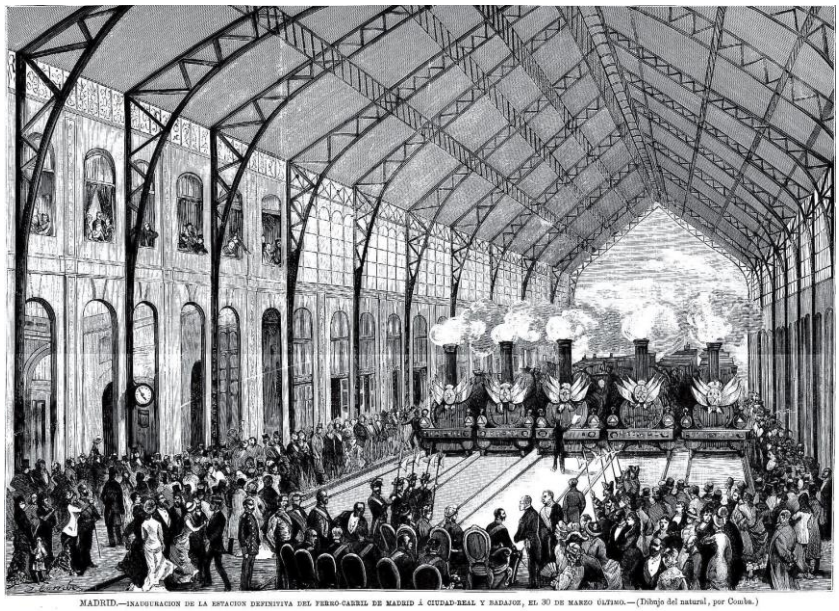
6.1 MADRID-DELICIAS: ORIGINS OF THE STATION-MUSEUM

(The explanation of the station's history takes place outside the building)

The Delicias Station was originally erected to serve as the starting point for the Madrid-Ciudad Real-Badajoz route. However, as mentioned in the introduction, in the year of its opening, it became the final station for the Madrid-Cáceres-Portugal route. Why was it built in this location? There are several reasons:

- **Geography:** Since the city of Madrid is mainly situated in a hilly terrain, composed of hills, knolls, and slopes, train stations are located at the lowest possible levels. This helps overcome the gradients that trains must navigate when entering or leaving the stations.
- **Strategic:** The existence of the contour line connecting the then stations of Atocha and Norte allowed for the interconnection of passenger and freight traffic with different lines, especially with France through the Norte line.
- **Centrality:** Proximity to the city's nerve center, the Puerta del Sol, and other important squares such as Antón Martín, facilitated the arrival of passengers and the distribution of goods from the station.

Typologically, the station follows the basic scheme of two parallel buildings, one for arrivals and the other for departures. Between these buildings, there is an iron framework covering the tracks and platforms. The height of the nave is noteworthy, opened by a cut at its highest point, as well as the enormous number of openings without glass that promote ventilation to dissipate train smoke. However, in winter, this makes it an inhospitable, cool, humid, and drafty place. The station was located at what were then the outskirts of Madrid, in a small valley with no entry inclines and associated with a railway ring road that existed at the time.



MADRID.—INAUGURACION DE LA ESTACION DEFINITIVA DEL FERRO-CARRIL DE MADRID Á CIUDAD-REAL Y BADAJOZ, EL 30 DE MARZO ÚLTIMO.—(Dibujo del natural, por Comba.)

Image 3: Natural drawing of the station's inauguration. Juan Comba.
La Ilustración Española y Americana magazine, April 8, 1880. AHF-MFM

Materials Used:

- The station features exterior facades constructed with brick, using common brick below the wide iron roof. Bands or rows of white facing bricks are alternated with rows of red and black bricks, creating a polychrome effect that adds visual appeal to the whole structure.
- The use of iron allows the roof to be supported without the need for keystones or components that could interrupt the general flow of passengers.
- The zinc decorations were replaced with wrought iron or cast iron ones, while the slate roof finish of the main nave was substituted with a basic finish of corrugated and galvanized sheet metal.
- Glass is also used to allow natural light into the main nave, and other materials such as granite for the baseboards and wood for the windows and doors are employed.

(Students can be asked about the materials used in the construction to introduce the era of the Industrial Revolution and how factories were built, taking advantage of the view of the chimney of the old El Águila brewery from the front of the station.)

The station was designed by the French civil engineer Émile Cachelièvre, who also oversaw the construction of the iron structure. The pre-assembly of the structure was carried out at the workshops of the Fives-Lille company in France. Several Spanish architects and specialists participated in the development of the station, including Gutiérrez Calleja, Bonifacio Espinal, and Enrique Ulierte.

Émile Cachelièvre used a construction technique similar to that employed by the French architect Henri De Dion in the Galerie des Machines at the 1878 Paris Universal Exposition to design the roof of the central nave of Delicias Station. The close temporal proximity between the construction of the station and De Dion's gallery adds even more value to the work from an architectural and artistic perspective, especially considering that the Galerie des Machines was demolished after the exposition. Henri De Dion slightly collaborated in the design of Cachelièvre's station, which is interesting and reflects the era in which both architects lived. As an interesting fact, it is worth noting that De Dion was the mentor of Gustave Eiffel, the architect who built the iconic Eiffel Tower in Paris.

Delicias Station is an example of the modern projects created to meet the spatial needs of the new industrial society, moving away from traditionalism. In this regard, the fine smoothness of the cladding and the extraordinary spaciousness of the areas stand out, achieved thanks to the new components and materials that artists of earlier years did not have at their disposal and which allow for minimal use of stonework. To enclose the space of railway stations, nothing compares to iron, which offers great weight resistance with minimal material, and glass, which protects it from the air and, thanks to its transparency, reflects essential light into its interiors.

6.2 HOW DID DELICIAS BECOME THE RAILWAY MUSEUM OF MADRID?

(This explanation can continue outside or be given at the entrance)

The idea of creating a railway museum to preserve, safeguard, and oversee railway objects, such as locomotives, carriages, and other relevant trains, had been present for a long time. However, the Spanish Civil War and its consequences postponed the creation of such a historical center until 1948, the year when the centenary of the railway line that marked the beginning of trains in peninsular Spain, the Barcelona-Mataró line, was celebrated.

Interestingly, the first Spanish railway line was built in Cuba, between Havana and Güines, in 1837. The centenary celebration served to reactivate the project of creating a railway museum in Spain, using the historical material exhibited on that occasion as a starting point.

(You can take this opportunity to ask visitors if they know when the first train in Spain was built, playing with the surprise that it was in Cuba instead of the Barcelona-Mataró line.)

The frenetic activity at this station, which had been in operation since its inauguration, definitively ceased in 1971 and it had to remain forgotten for about ten years until an agreement between RENFE and the Public Administration restored its lost utility.

Initially, a salon-type museum with models, engravings, and small objects was created on Calle de San Cosme y San Damián (Madrid), which served as a foundation for what was to come, accommodating locomotives, passenger cars, motorcars, and wagons.

When the documentary collections and historical objects from San Cosme y San Damián were moved, and the essential trains for the collection that would be displayed were recovered and refurbished, as well as the structure of the building itself, it was inaugurated as the National Railway Museum on December 19, 1984. The railway began to roll.

6.3 The Railway Begins to Roll

(This explanation can be given at the entrance of the museum, near the small 020PT steam locomotive, as an introduction to the museum for visitors)

Image 3: 020PT Steam Locomotive. Photo property of the Railway Museum of Madrid.

How Did We Get to High-Speed Trains? It all began in ancient Mesopotamia. The passage of carts along roads, streets, or highways created ruts or tracks known as "wheel marks," which, in ancient Sumerian and Babylonian cities, were preserved by paving the roads so that drivers

could guide their carts more easily. Evidence of this guiding system, dating back over 4,000 years, can be found in excavations of these cities.

(You can ask visitors if they know where tracks were first used.)

Rails, as we know them today, appeared in the mid-16th century in Central European mines to facilitate the movement of carts carrying materials in excavations. Initially, these tracks were simple wooden planks, but in 1750 they were replaced by iron rails. To prevent derailments, different strategies were tried, from notched and grooved rails, rails with flanges and smooth wheels, to smooth rails and wheels with flanges prevailing.

(We can reference the use of this type of carts or rails in video games like "Minecraft" for younger visitors.)

In 1712, the Briton Thomas Newcomen built the first steam engine, used as a pump to extract water from the bottom of mines. In 1769, another English inventor, James Watt, improved the steam engine. This much more sophisticated and adjusted machine began to be used in textile workshops.

Shortly afterward, the idea arose to use the motion developed by the steam engine to move the wheels of a carriage. One of the first to design a motor vehicle was the Frenchman Joseph Cugnot, who in 1769 built the *Fardier*, a carriage difficult to control that caused many protests and anger in Paris, where it was presented. This led efforts to focus on vehicles on rails.

It was Richard Trevithick who, in 1808, devised a functional train that was introduced as a fair attraction. For a coin and on a small circular track, people could take a ride in carriages pulled by a train called "Catch Me Who Can."

(We can make a reference to the differences with current fair attractions, many of which use rails.)

However, George Stephenson is considered the "father of the railways," building the first proper trains. His locomotive Locomotion inaugurated the world's first railway line between the English cities of Darlington and Stockton in 1825, initially used to pull freight wagons. Five years later, on September 15, 1830, the first intercity passenger railway line was introduced between Liverpool and Manchester. The Rocket locomotive was chosen in a competition held previously for this line, defeating its four competitors with designs quite different and alternative to Stephenson's. From this moment, the expansion of railway lines in Europe and the world began to be noticeable.

In a short time, France, Germany, and the United States began to manufacture their own trains and lines. In the U.S., the small train Tom Thumb of 1830 was the first to run in this nation. Before its regular use, a competition was held against a horse-drawn carriage on a stretch of horse-drawn railway between Baltimore and Ohio, where the horse won. It would be necessary to wait until the late 1830s to see the first public steam train service in the United States, specifically in Charleston with the train Best Friend of Charleston.

In Spain, to trace the first steps of trains, we must go back to the construction of the first line in 1837. This work was carried out on the island of Cuba, then part of Spanish territory, establishing the route between Havana and Bejucal, later extended to Güines. This line was intended for sugar transportation, given the commercial importance of this product and its significant contribution to the island's and Spain's economy at that time.

In the Iberian Peninsula, despite bureaucratic obstacles and initial reluctance towards railway construction, the first railway line was inaugurated in 1848, connecting Barcelona and Mataró. Three years later, in 1851, the second line was inaugurated between Madrid and Aranjuez,

known as the "strawberry train." From then on, the development of railway lines began to be notably noticeable. By 1865, about 5,000 km of tracks had been built by large railway companies that emerged in the era of modernity. The main lines were owned by M.Z.A., Caminos de Hierro del Norte, and the Andalusian Railways Company, leaving the rest of the railway companies relegated to short and nearby routes, except for M.C.P., which owned Delicias Station.

(We can reference that if they visit Atocha Station, from the outside, they can see the words Madrid, Zaragoza, and Alicante on the metal cornice, showing that these are not destinations but the names of the station's owners, M.Z.A.)

(We can also play outside with the students to find the initials of M.C.P. or Madrid-Cáceres-Portugal on the crests that crown the gabled roof of the cornice.)

After the Spanish Civil War, all railway companies were nationalized, and RENFE was created.

6.4 THE INFLUENCE OF THE RAILWAY ON SOCIETY

Traveling before the advent of the railway was quite an adventure. The main modes of transport were ships by sea, horse-drawn carts, and stagecoaches by land. Stagecoaches were a slow means of transport, barely exceeding 10 km/h. Traveling between cities by this means was quite a feat, requiring several days and a series of infrastructures or buildings to carry it out. These buildings were coaching inns and lodgings, and their operation required a lot of personnel for a few stagecoaches with not many seats, which was reflected in the cost of the ticket. Frequently, only the wealthiest classes could afford this type of travel.

The advent of the train was a revolution in itself. It greatly expedited travel, adding comfort and reliability, as there were set schedules to meet. This allowed for better planning of stays at destinations. Now, trips could be made in a couple of hours, leaving behind long travel days and even allowing for round trips to a destination in a single day. Train lines could transport a much larger number of people, and third-class ticket prices were reasonable for the less affluent classes, thus opening up the possibility of travel to these social classes.

Products produced in different parts of the country could be shipped at a minimal cost and in a short time without the goods spoiling, which greatly favored commerce. The economy of the provinces crossed by railway lines quickly changed from a self-sufficient and closed economy to a more open economy of trade in raw materials and manufactured goods.

At the same time, all the railway routes changed the landscape, both in rural areas with the laying of tracks and in metropolitan regions with stations, warehouses, and industrial areas that emerged around them. The presence of railways was one of the crucial components for the Industrial Revolution and the dynamization of commerce.

6.5 STATIONS

At first, train stations were simple places where trains stopped for passengers to get on and off. To protect passengers from the weather, these stations were covered to avoid rain or snow. With the growing popularity of railways, the expansion of their use as a means of transport, and the centralization of several lines in one place, large stations were built offering a wide range of services and amenities to travelers. This is how the first recognizable stations were born, many of which are still in use and hold great historical value.

These places offered storage areas for luggage, such as lockers, motels, inns, bathrooms, left-luggage offices, rest areas, and waiting rooms. Today, major stations like Atocha still offer a wide variety of services, and some, like Príncipe Pío Station, even house a shopping center inside. In the past, different social classes did not mix, so there were separate rest areas for first, second, and third class, each with its own amenities and luxuries. Additionally, these stations housed

necessary elements for daily operations, such as offices, workshops, lights, and the station master's office.

6.6 THE MIKADO AND THE OPERATION OF STEAM ENGINES

(It is advisable to approach the Mikado locomotive, which is cut in half, to explain its operation, pointing out the different elements to the students by the colors with which they are painted.)

Image 5: Mikado Locomotive. Photo property of the Railway Museum of Madrid.

On the right and central platform, we will have the opportunity to see a wide variety of steam trains and simultaneously observe the evolution of these trains from the earliest models to the most modern ones. The first locomotive we encounter upon entering the station is the "Mikado," which has been cut in half and painted inside to allow a view of its interior and a better understanding of its operation. At the back of the locomotive, we find an auxiliary wagon known as the tender.

To understand how a steam locomotive works, we start with an explanation of its different parts and colors (but first, we ask visitors what the two essential elements for its operation are: water and coal):

- The **cab** or canopy is where the driver and the fireman are located, responsible for operating and feeding the locomotive.
- The **firebox**, painted yellow for distinction, is located just before the cab. Here, the fuel is burned to generate heat. First, the firebox door is opened, and rags soaked in petroleum are inserted to light them. Then, wood is added, and when there are embers, coal is thrown in.
- The hot gases generated in the firebox exit through openings located at the front of the firebox, continuing through blue-colored tubes that pass through the boiler, which contains the water needed to generate steam. These smoke tubes are heated by the gases, in turn heating the water surrounding them. When the water reaches 100°C, it turns into steam.

- The steam is collected at the top of the **boiler** in a piece called the **dome**, recognizable by its characteristic semi-spherical shape. From there, the steam is conducted through red tubes and passes again through the smoke tubes in a space called the **superheater**, to further increase its temperature and pressure.
- The movement of the locomotive occurs when the steam reaches adequate pressure. This cycle, from ignition to reaching the necessary pressure, takes approximately three to four hours.
- How is movement produced? To transform heat energy into motion, the **cylinder** is used, an element inside which the movement of the **pistons** occurs thanks to the force of the steam. Above the cylinder is the **distributor**, whose mission is to send the steam from one side to the other of the cylinder to push the piston. The steam enters the distributor at high pressure and is sent to one side of the cylinder, pushing the piston to the opposite side. This process, repeated several times, causes the piston to move back and forth constantly, transmitting this movement to the driving wheels through the **connecting rod**s. The connecting rods convert the straight movement into circular motion, causing the wheels to turn, producing the "rod-crank" movement.
- The driving wheels are responsible for providing power to the locomotive; the greater the number of wheels, the greater the power. The additional wheels only support the weight of the locomotive and have no driving function.
- The **tender** is an auxiliary wagon that contains the essential consumable components for the train's operation, such as water and fuel. Coal is the most commonly associated fuel with steam trains, although more modern trains use fuel oil, a liquid fuel that is easier to refuel and reduces the work of the fireman, who used to handle up to one and a half tons of coal per trip. In the tender, water is distinguished in green and coal in brown at the top.

6.7 LICENSE PLATES

(Approaching the next locomotive and emphasizing that its tender is incorporated because it would be a locomotive for shorter journeys. It is also usually helpful to ask them if they know what a license plate is, comparing them to car license plates.)

With the creation of RENFE in 1941, a change occurred in the way steam locomotives were classified. Until that time, each railway company classified them in a heterogeneous manner without following a standard. With the intention of unifying criteria, a seven-digit license plate was implemented, allowing several details of the locomotive to be known at a glance. This measure facilitated the work of railway workers and contributed to improving the efficiency of locomotive use.

The first three digits of the license plate correspond to the axles of the locomotive. According to the arrangement of their driving or carrying axles, we can identify the type of locomotive. There are three types of differentiated wheels:

- The front carrying axles
- The central driving axles
- The rear carrying axles.

The carrying axles can be grouped in "bogies," in bevel-type axles, or included in the frame of the locomotive itself. If there were no carrying axles, a "0" was marked on the corresponding license plate.

Image 6: Detail of the license plate of the 120-0201 steam locomotive.

Image 7: 120-0201 steam locomotive.

Between the first group of three digits and the second group of four, a hyphen was usually used to separate them, which later would be replaced or accompanied by the letter "F" if the locomotive was fueled, meaning it used fuel oil instead of coal.

As an example, besides the locomotive shown in the images, we have the sectioned "Mikado" locomotive from the beginning, which is globally known by the license plate 1-4-1. When the locomotive had a separate tender, the fourth digit indicated the number of cylinders. In our "Mikado" example, it would be 2. For tank locomotives without a tender, this fourth digit will always be zero.

6.8 Start Up

(Getting on the next train or locomotive and with them inside the tender, we begin the following explanation)

How was a steam train started? We mentioned that it took about three hours to prepare it for operation, and once ready, the driver and the fireman would board to operate it.

Before starting their journey, the conductor had the task of completing the route sheet provided by the station master, which included the duration of the trip, the departure time, and the destination. Then, the train start-up process would begin, where the driver would sound the whistle, release the brake, and adjust the regulator, which controlled the amount of steam entering the cylinders. By adjusting the regulator, the driver controlled the train's speed according to the route signals.

The fireman had a crucial role in the operation of the steam train. It was his responsibility to supply the firebox with fuel to maintain the steam pressure at the appropriate levels, ensuring the locomotive's proper functioning. Additionally, he supervised the water level in the boiler and refilled the tender if necessary. In collaboration with the driver, he ensured the track was clear to avoid collisions and assisted in curves and other maneuvers requiring his expertise and skill.

The brakes worked with brake shoes that pressed against the edge of the wheel (similar to bicycle wheels, to help visitors understand). Given the extraordinary load and weight of a train at a certain speed, a long distance was required to stop. For example, today’s high-speed trains brake 10 minutes before arriving at the station. To increase the adhesion of the brake shoe and facilitate deceleration, sand was used. Sandboxes were placed, which, through a simple system, dropped the sand through ducts onto the track before the driving wheels. This improved the effectiveness of the train’s deceleration and, therefore, braking. This technique is also used by electric and diesel trains. (In fact, this can be demonstrated in the diesel locomotive area, near locomotive 4020, by showing the sandboxes and part of the sand that was used.)

6.9 CLOCK ROOM

The clock and the railway form an inseparable duo. The clock was, and still is, essential for the proper functioning of trains, as departure and arrival times, coordination to avoid collisions, and track switching, among other aspects, depend on it. Due to the need for exquisite precision in timekeeping, stations soon became filled with clocks, which is why we find them on facades, lobbies, and platforms.

To facilitate railway circulation, the use of standardized time was implemented in 1901. Until then, each region used solar time to synchronize their devices, resulting in time differences between provinces of more than 40 minutes, which was chaotic for railway workers.

Image 8: Clock Room. Photo property of the Railway Museum of Madrid.

Before the unification of time in Spain, it was agreed in 1878 to use the time from the Royal Astronomical Observatory of Madrid to synchronize the clocks at railway stations via telegram. This caused civil time to be desynchronized with railway time. Therefore, in 1901 it was decided that Spain would adhere to the 1884 Washington agreement, which divided the planet into 24 time zones, allowing for better railway coordination. Thus, from January 1, 1901, the Greenwich meridian became the time reference throughout the country.

The Mataró Clock was the one that marked the departure of the first railway on the peninsula in 1848, the Barcelona-Mataró. It was placed in a small temple to give more prestige to such an illustrious ceremony.

There are also tall case clocks and porthole clocks, among others. These clocks were set by the supervisor when the telegram with the exact time was received, an action that was usually performed once a week. In this room, you can see "standard clocks" that served as guides for the other clocks and for comparing and "passing the time" from one clock to another. It was the station master who was responsible for setting the time on these clocks when the telegram from the Observatory was received.

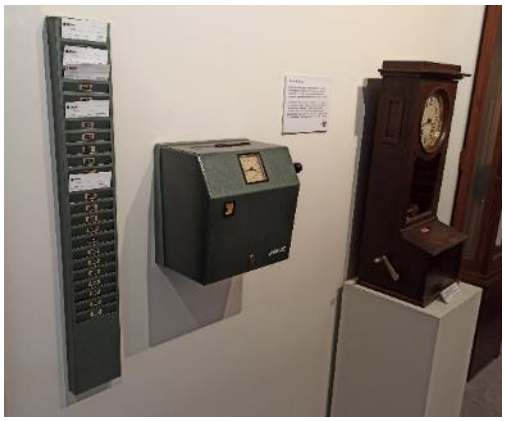


Image 9: Time clock machines in the clock room

Other notable objects in this room are the time clocks used to ensure employees worked the required hours, the night watchman clocks, and the travel guides.

6.10 SIEMENS AND ELECTRIFICATION ON THE TRAIN

(In the next corridor, facing the electric locomotive 7420 and with your back to the diesel locomotive 4020)

At the end of the 19th century, an innovation in railways occurred with the introduction of electric power. One of the pioneers of this technology was the German designer Werner von Siemens, who presented a model at the Berlin Universal Exhibition in 1879. This small train was equipped with an electric motor and was powered by a third rail located between the two main rails. It was able to reach a speed of 13 km/h, marking a milestone in the history of railway transport.

This prototype was dangerous, so the power supply system was replaced by a wire called a catenary, suspended above the train and supported by poles. The catenary carries the electric current. Thus, the train obtains electrical energy from the catenary through the pantograph, which transfers it to the train's electric motors. The pantograph, located on the top of the train, is a device with components that facilitate its elevation, making contact with the catenary through copper contact strips.

Image 10: Electric Locomotive 7420.

(We can take the opportunity to make an analogy with bumper cars, Scalextric, or even the subway to help them better understand the mechanism.)

The benefits and advantages over steam trains drove their gradual implementation until they replaced steam. The power of an electric motor is much more efficient and potent than that created by a steam train, allowing electric trains to overcome slopes that were impossible for steam trains. Additionally, they were much faster, less noisy, and easier to operate than steam trains. They did not pollute as much, and their energy consumption was lower and more efficient.

The fundamental drawback of these trains was the cost of constructing an electric line. In addition to the poles and the catenary, support systems for the catenary had to be added, and electrical substations had to be built to reduce the high voltage of the lines and make this energy usable by the locomotives.

The fact that they did not emit smoke and did not pollute as much is the main reason why electric railways prevailed in suburban trains of the cities. Thus, in 1890, the first electric metro was inaugurated in London, and in 1896 the first continental metro was introduced by Siemens in Budapest.

The first electrified railway section in Spain was built in 1911, between Gergal and Santa Fe (Almería), a mining railway section with many inclines, which led the owning company to electrify it. The second electrified section was built in Puerto de Pajares, which, due to its number of tunnels and slopes, was very difficult for steam trains. (There is a model of Puerto de Pajares in the last room of the museum that we can later use to support the explanation of this fact.)

Finally, it should be noted that of the total kilometers of network managed by ADIF and ADIF-AV (the current company that manages the railway networks in Spain), 61.7% runs on a single track and 35.8% is not electrified. Additionally, only 19.5% corresponds to the international UIC gauge (3,014 km).

Link to the map of the Spanish railway network.

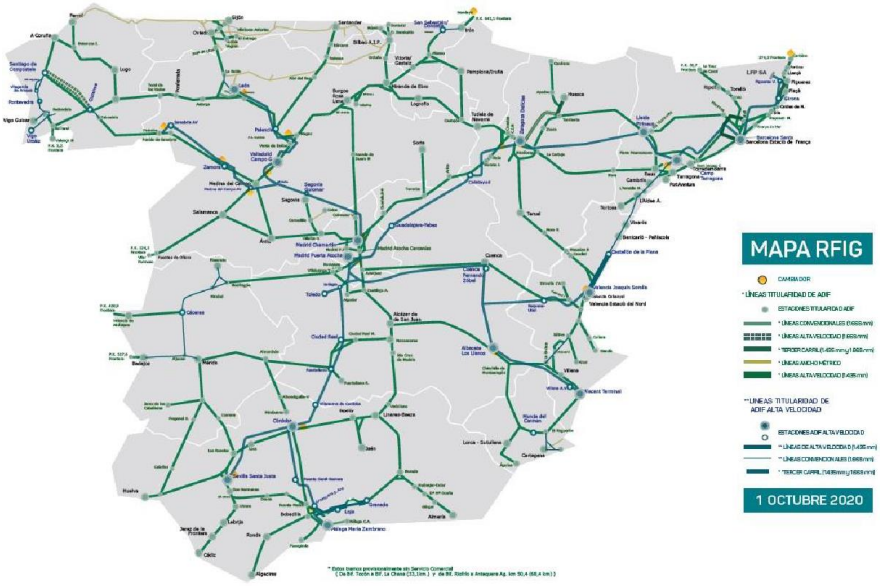


Image 11: Source. RFIG Map. ADIF Network Statement.

6.11 THE DIESEL ERA

(This explanation would be given near the diesel locomotive 4020. You can ask the question about which locomotive was invented first, the diesel or the electric one.)

Rudolf Diesel, a German engineer and inventor, designed the engine that bears his name in 1893. In 1897, he worked on the first design of this engine, which continues to be used in the 21st century with modifications.

The diesel engine is characterized by having much higher compression ratios and longer combustion, which means that the temperature rises more slowly and allows a greater amount of heat to be converted into mechanical work. Initially, Rudolf Diesel tried to make the engine run on vegetable oil or coal dust, and he succeeded in running it on vegetable oil. This type of engine is commonly used in locomotives due to its ability to provide high torque and a low number of revolutions per minute.

These engines operate on a four-stroke cycle. The engine has cylinders in varying numbers, in which a mixture of air and fuel is injected and compressed inside the cylinder by the action of a piston. This pressure causes the temperature inside the chamber to rise, making the fuel detonate. This explosion displaces the piston, which then, with the help of a connecting rod, moves a crankshaft, whose axis will turn a wheel called a flywheel, which will eventually transmit its motion to the wheels of the train or locomotive.

This type of engine presents great benefits and advantages for diesel trains. They are more efficient, occupy little space, and their size is similar to that of electric train engines. Their incredible autonomy stands out as they do not require installations that entail large investment costs such as electrical substations, poles, and catenaries.

Image 12: Diesel Locomotive 4020.

Diesel trains are commonly used on railway lines with low traffic where electrification is not cost-effective. Additionally, they are frequently employed in station maneuvers through diesel shunting tractors (small diesel locomotives used in stations, workshops, and depots for assembling trains and wagons).

On the other hand, a very peculiar type of diesel train became popular: the railcars, trains where the locomotive and the passenger car are one unit. These railcars had moderate fuel consumption, maintenance stops were brief, and they were ready to depart once they arrived at the station, with the driver only needing to switch cabins, which reduced waiting times. Several railcars can be found in the museum, such as the diesel railcar 9522. At the end of the visit, we can show several of these examples.

6.12 TOWED MATERIAL

(*At this point, we are approaching the final phase of the visit. This content is usually explained near the walkways that allow visitors to see the interior of passenger cars or other towed material on display.*)

In this section, we will refer to passenger cars. Among the passenger cars, we have the opportunity to observe and visit first, second, and third-class cars, allowing us to reflect on the distinctions in terms of luxury and economic solvency among the different classes. In this way, social inequality in the early days of railways could be experienced firsthand: passengers who could afford a first-class ticket traveled more comfortably and luxuriously than those who used second-class and especially third-class cars.

The first car we will talk about is the RENFE ZZ-307 Saloon Car from 1946. These saloon cars were used for railway journeys by authorities, high-ranking railway company officials, and wealthy individuals. These truly luxurious cars, for which no expense was spared in terms of material quality and finishes, were usually owned by wealthy individuals, public organizations, or railway companies. To use this type of car, it was enough to attach it to any of the regular trains running on the line where the person in question wanted to travel. This car was assigned to the Renfe Directorate at Atocha Station, Madrid.

Image 13: ZZ-307 Saloon Car.

This car has a very striking layout; it features a meeting lounge at one end with a glass-enclosed area that allows for enjoying the views and was used for track inspections when management personnel traveled in it. From the walkway, we can observe other rooms along a corridor, such as: a bathroom with a shower, a single bed with a sink, a ready-to-use kitchen, and a room with bunk beds and a toilet.

Image 14: Interior detail of the ZZ-307 Saloon Car

Image 15: Interior detail of the ZZ-307 Saloon Car

Image 16: Interior detail of the ZZ-307 Saloon Car

The car stopped being used in 1987, being donated by RENFE to the museum for restoration and exhibition.

The next car we are going to present is the JMR Saloon Car from 1902, which belonged to the Basque businessman José Martínez Rivas. This luxurious car was acquired at the beginning of the 20th century for his personal use and, like the previous case, could be attached to any train to travel on the desired line. In its interior design, this side-corridor saloon car included a lounge, a sleeping compartment, and a toilet in the center. It is worth noting that during the Spanish Civil War, this car was used as a "relief train" in Alsasua and had to be transformed to adapt to its new function. In 1977, RENFE donated the car to the museum, which restored it to its original state in 1984.

Image 17: Interior detail of the JMR Saloon Car

Image 18: Interior detail of the JMR Saloon Car

Image 19: Interior detail of the JMR Saloon Car

Now we will talk about a third-class car. After the previous luxury, the contrast between the cars is striking. This is the C-16 Passenger Car of the Lorca-Baza-Águilas Railway. This piece belonged to the L.B.A. (Lorca to Baza and Águilas Railway Company). The C-16 entered service between 1889 and 1891. By today's standards, it is surprising that it was once considered the most modern, luxurious, and comfortable. However, it is important to remember that in the early years of the railway, travel conditions were extremely difficult, especially for third-class passengers. In addition to enduring the constant and annoying rattling of the train, these travelers suffered from overcrowding in compartments with hard wooden seats. Although the cars of this company originally had windows with glass, the discomforts were considerable. Notably, its layout lacks an interior corridor for communication between compartments; access to the interior was from the sides. These sides had footboards that the conductor could use to hold on to and check passengers' tickets while the train was in motion. The capacity of this small passenger car is 60 passengers, with five compartments of 12 seats each. Lighting was provided by oil lamps installed in the ceiling. These lamps were refilled and lit from the outside, accessed via the steps located at both ends of the car. In 1978, it became part of the collection and was restored in 1984.

Image 20: Third-class Car C-16

The lighting in the early cars was done with oil and petroleum lamps, then with gas, and finally with electricity. The heating in many of these cars consisted of heaters that acted as thermos or metal structures filled with hot water that were replaced at each stop and heated the compartment. In the trains exhibited in the museum, we will have the opportunity to observe some of these containers. It was towards the end of the last century when the entire train was heated thanks to a tube associated with the locomotive that used the generated heat to warm the passengers.

Image 21: Detail of the interior of the 3rd class Car C-16

In the United States, due to the vast distances between cities, the idea of creating sleeper cars emerged. Entrepreneur George Pullman was the pioneer in their creation and, years later, commissioned the construction of the first dining car. In Europe, this innovation was imported by Belgian financier Georges Nagelmackers, who founded the renowned international sleeper car company "Georges Nagelmackers & Company," later known as "Wagon-Lits."

Now we will visit from the outside the Restaurant Car R12-12954. It was originally conceived as a "Pullman" car for the Compagnie Internationale des Wagons-Lits (CIWL), which operated lines in Europe. With the stock market crash of 1929, they had to be transformed into restaurant cars

to make them profitable. In 1964, they began operating in Spain for that purpose. In 1988, RENFE purchased five cars of this type from the Wagon Lits company to create a luxury train and recreate the 1920s with modern comforts. Finally, the trains were handed over to the museum in the 1990s for use on special occasions.

Image 22: Restaurant Car R12-12954.Photo property of the Railway Museum of Madrid.

6.13 THE TALGO II

The TALGO, abbreviation of Tren Articulado Ligero Goicoechea Oriol (in English: Lightweight articulated train Goicoechea Oriol) was a revolutionary project developed by a Spanish company, born from the collaboration between designer and engineer Alejandro Goicoechea Omar and businessman and politician José Luis Oriol Urigüen. Since then, it has patented several mechanical developments, such as the automatic track changing system or natural tilting systems.

In 1941, the first tests were carried out with the Talgo I between Madrid and Guadalajara, reaching speeds of 135 km/h. Later, in 1950, production of the Talgo II began, this time in the United States due to the precarious state of the Spanish industry in the post-war period. The first journey of a Talgo II in Spain was made on the Madrid-Irún line.

Image 23: Talgo II

The major innovations presented by this model were several, including guided rolling, an articulated composition, and a lightweight aluminum body. It was also a pioneer in other aspects, such as its new design that allowed passengers to have platform-level doors, anatomical seats with reclining armchairs, air conditioning, catering service to passengers in their seats, and panoramic windows to admire the landscape.

Image 24: Talgo II locomotive. Photo property of the Railway Museum of Madrid.

The TALGO II is a much more modern vehicle than its predecessors and comes with several notable improvements. It is shorter and lighter, has a more aerodynamic profile, and sits lower, which, along with the aforementioned, allows it to achieve higher speeds. Additionally, its articulated design enables smoother handling on curves, providing great comfort for passengers. Since then, passengers no longer needed to be exposed to the elements to move between cars,

avoiding the dangerous accordion-style platforms of the past. This is something we can see every day in modern subway cars that allow us to move from one end of the train to the other without stepping outside.

Image 25: Talgo II. Photo property of the Railway Museum of Madrid.

6.14 Model Room: Railway Territory

(*Following our tour, we will go up to the second floor of the museum to discover the impressive "Railway Territory" model. Before entering the room, there will be a brief introduction to the model and the exhibited pieces.*)

In this room, we can find the largest railway model in Spain and one of the most spectacular in Europe, where visitors can see moving replicas of some trains exhibited at the museum station on a small scale (1:87). With an area of 300 square meters in a 'U' shape, the "Railway Territory" model was conceived in 1998 to commemorate the 150th anniversary of the Railway in Spain. The model has been recently restored and digitized, featuring interconnected circuits capable of handling 66 trains. Its automatic operation is regulated by traffic lights and digitally controlled, allowing for realistic traffic management. At this stop, visitors can observe the different facilities and elements that make up a railway line, making it easier for children to create an image of trains in motion.

In addition to having light and sound effects, the model features a detailed landscape that evokes both wet and dry Spain, including urban areas, industrial areas, towns, and a network of roads and highways with bridges and tunnels. It also includes a port area with docks and cranes, and reproduces emblematic places of the Spanish railway network, such as the viaducts of Martín Gil and del Salado, and the stations of Gijón, Toledo, Azpeitia, and Seville Santa-Justa, among others.

IImage 26: Detail of the "Railway Territory" model. Photo property of the Railway Museum of Madrid.

6.15 RAILWAY INFRASTRUCTURE ROOM

In the railway domain, having adequate infrastructure is crucial to ensure the efficiency of train circulation. For this purpose, Track and Works Services were created, which are responsible for ensuring the maintenance and good condition of elements such as tunnels, bridges, rails, sleepers, among others.

Over time, this department has become more sophisticated to include tasks such as maintaining traffic signals, mechanical interlockings, as well as supervising electrified lines.

HOW IS A RAILROAD TRACK BUILT?

During the early years of railroad construction, most of the work had to be done by hand. The lack of specialized machinery and the complexity of the terrain made building a railroad line a difficult and expensive task. Laying the track was one of the most costly tasks, both in terms of materials and labor.

To build railroad lines, teams of workers willing to work long hours in adverse conditions were needed. Additionally, a large number of workers were required to perform the necessary tasks, as the work was extremely exhausting and dangerous, leading to many becoming ill or injured during the construction process.

Despite these challenges, railroad construction was successfully carried out. Over time, new techniques and machinery were developed, making the construction process faster and more efficient, although the construction costs remained significant.

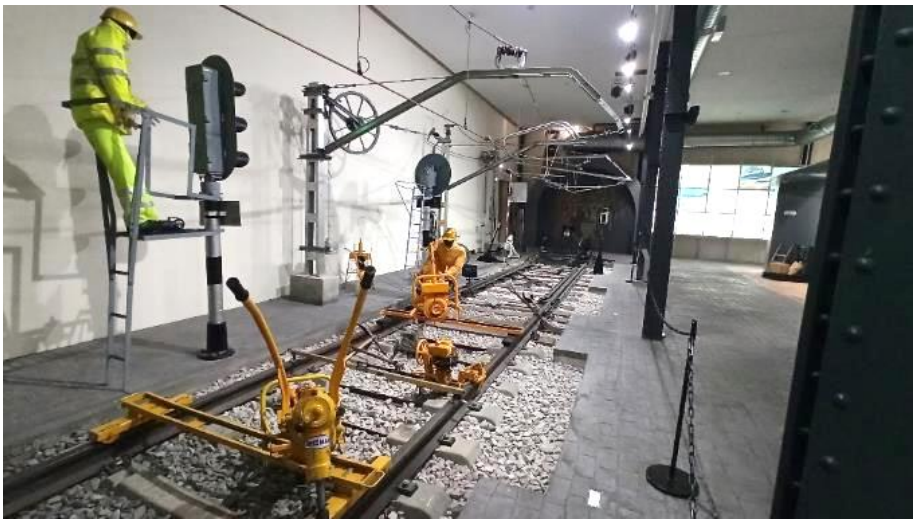


Image 27: Interior of the infrastructure room

Due to the early trains lacking sufficient power to overcome steep gradients, often longer and more suitable routes had to be taken to avoid these issues on the line. This involved detours and longer paths to navigate the terrain's difficulties and ensure the railways operated correctly in their early development stages.

Constructing a railway track is a complex task that requires meticulous preparation and assembly. It is crucial that the track is well-settled and leveled, without steep gradients, and with a compacted soil that can withstand the weight and vibration of trains. To achieve this, a process is followed in which the soil is compacted, and a layer of ballast, usually made of granite, is laid. The primary function of the ballast is to drain rainwater and prevent the soil from becoming uneven over time. Additionally, the ballast acts as a cushion for impacts generated by passing trains and evenly distributes the weight on the track.

On top of the ballast, sleepers, initially made of wood and nowadays of concrete, are placed perpendicular to the track. The sleepers support the rail, to which they are fixed using seat plates and long bolts. The rail is the element that allows trains to move and is where the train wheel rests. Thanks to the rail's flange, the wheel is prevented from derailing, and wear and tear from rolling are reduced. This entire assembly, from the compacted soil to the rail, forms the basic structure of the railway track.

Image 28: Type of ballast

Image 29: Type of ballast

Image 30: Type of ballast

HOW DOES TRAIN CIRCULATION WORK?

Signaling is one of the most essential components in the world of railways, as its correct implementation helps prevent serious accidents such as collisions, derailments, and crashes. The main objective of signaling is to ensure that trains do not run head-on into each other, as well as to ensure "blocking distance," which means a safe distance between trains in the same direction to prevent collisions. Signaling is carried out through visual and auditory signals, and its correct interpretation is crucial for safety in railway traffic.

Next, we will see an evolution of the elements that were necessary to ensure this proper control, from signals with the arm to modern electronic systems that ensure passenger safety, making the railway one of the safest means of transportation.

Switches were a key element in allowing trains to change direction. At these points, trains could take different routes thanks to the switch points. The switch points were a movable part of the tracks that allowed movement in various directions to change the train's direction. Generally, they were operated by a switchman. At each switch point, there was always a switchman, and it was the station master who ordered when to move the switch by operating the corresponding lever. Additionally, the station master was also responsible for managing the signaling, whether manual or light signals, to ensure the safety of railway traffic. Ultimately, the proper functioning of switches and signaling was crucial to avoid collisions, derailments, and ensure safety in train circulation. Currently, interlockings are controlled in computerized rooms from where the electric motors of the switch mechanisms are operated.

Image 31: Mechanical interlocking

RAILWAYMEN AND THEIR TOOLS

The often overlooked individuals when discussing the world of railways are typically the people who made their existence and operation possible. Thanks to the hard work they performed, these massive iron machines began to traverse the Spanish provinces up to the present day. Thanks to movies, where the railway is often a recurring element, the figure of the station master is one of the most remembered, as well as that of the ticket inspectors who diligently require our tickets when we are aboard a train.

Station masters have been responsible for ensuring trains depart on time with their characteristic whistle and flag, and above all, for ensuring they do not suffer any mishaps or accidents. We must also remember the ticket sellers who sell the tickets, nowadays being replaced by vending machines; the train drivers who operate the trains; the former firemen who maintained the correct pressure in the locomotives, among others. Ultimately, the world of railways would not be possible without the work and dedication of all the workers who make its daily operation possible. Although they are often overlooked, they are essential to ensure that trains can continue to circulate and fulfill their role as a fundamental means of transportation in our society.

In the museum, we can find part of the uniforms worn by these workers. One of the most iconic and striking elements of railway workers were their caps, which have a dedicated section within

one of the museum's rooms, where we can appreciate differences in occupations based on the emblems or symbols embroidered on them.

Image 32: Legend of railway caps

Other notable occupations that have fallen into obscurity could include the aforementioned switchman; the track watcher, responsible for monitoring the tracks; the night watchman, who patrolled the tracks at night to clear them of obstacles; the inspector, whose job was to inspect the rolling stock; or the lamplighters, who changed the colored lenses of the lanterns, repaired them, cleaned them, and illuminated the station, among others. Some of the lanterns and lights are exhibited in the museum, and it's quite fascinating the array of lenses they had for different signals. Many of these lamps and lanterns initially operated with oil and other fuels. Among these gadgets are tail lights, three-light lanterns, handheld flashlights, and even semaphore signals. These lamps were crucial for the proper functioning and circulation of the railways, as they were used to give way or departure to trains, control access, or for the station master to give orders to the switchmen.

As we mentioned earlier, the station master is always remembered alongside his inseparable whistle and flag. Inside the museum, you can find an interesting collection of these items, including horns that were sometimes used as an alternative to the whistle. These wind instruments were used by railway workers to communicate with each other in moments when the noise of the train and the surroundings made verbal communication difficult.

7. CONCLUSION AND FAREWELL

A visit to the Madrid Railway Museum is an enriching experience for students from Madrid and for all those interested in the history and evolution of railway transportation in Spain. Through the collection of locomotives, carriages, and other railway-related objects, one can understand the importance that this means of transportation has had in Spanish society since its arrival in the 19th century until today.

Furthermore, the museum offers an interesting perspective on the work of railway workers, who have often been forgotten. The collection of objects found in the museum demonstrates the importance of the small details and tools that were used in the daily lives of these workers.

The impressive collection of locomotives and carriages from different periods in the museum showcases the evolution of the railway in Spain. From the early steam trains to the modern trains of today, the museum highlights the importance of the railway in Spain's history and its impact on people's lives.

In conclusion, the Madrid Railway Museum is highly recommended for learning more about the history of the railway in Spain and the work of the railway workers who made its existence and operation possible. It is a unique opportunity to immerse oneself in the history and evolution of a mode of transportation that has been key to Spain's economic and social development.

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