The correct wheel load

Importance, influences and methods for adjustment

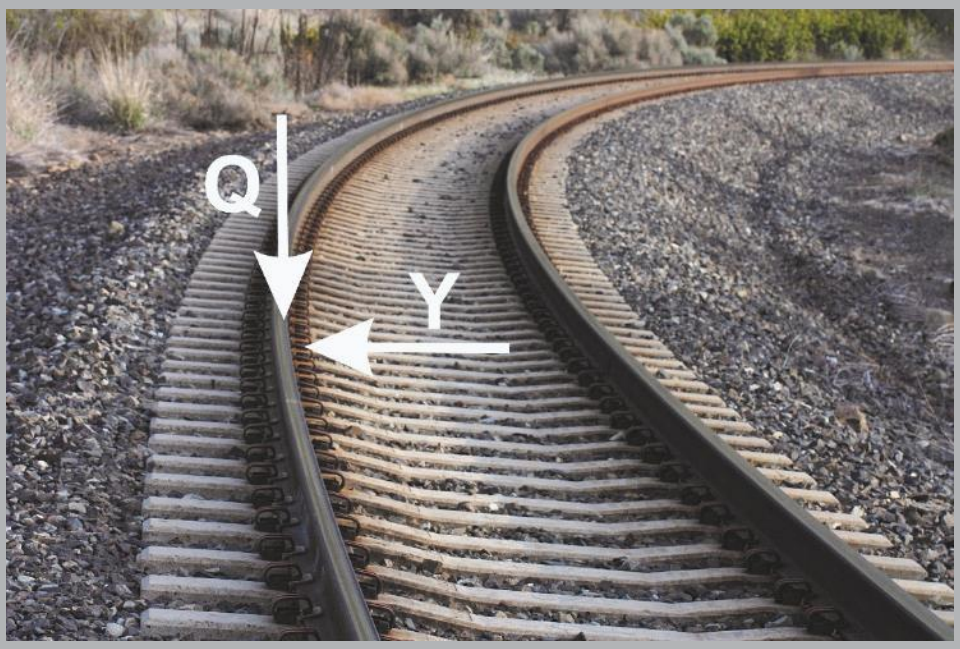
Introduction

Regardless of a freight, a highspeed, a normal speed or a mass transit train – nobody wishes for an accident caused through derailing. In the event of an incident, due to a faulty bogie, the operation of a complete metro line can be interrupted followed by immediate negative news headlines in the press and social media. A worldwide topic is the reduction of wheel wearing in order to minimize the life cycle costs of a train.

An important factor to reduce the mentioned problems and risks is to adjust and control the correct wheel load.

The importance of the wheel load

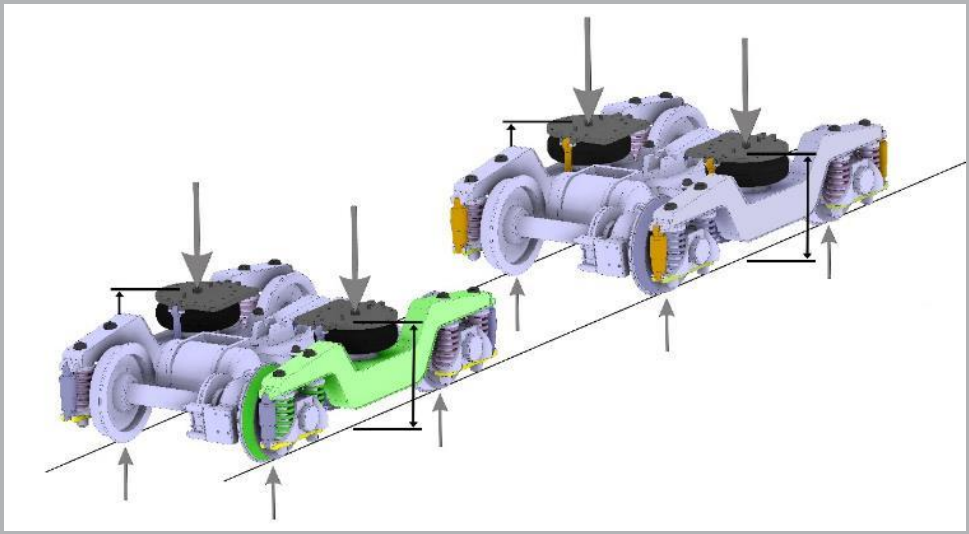
The safety against derailing depends on two important forces: the lateral force (Y) on a wheel, caused by lateral forces in curves, the sinus movement, side wind etc. In contrast is the vertical load, the wheel load (Q), which must be strong enough to withstand the lateral load. The typical maximum ratio between Q/Y should be < 0.8.



Safety against derailing depends on

What influences the correct wheel load?

The main factors influencing the vehicle's wheel load are the diameter differences amongst the wheels, the primary suspension, a possible twisted bogie frame, the height differences from top of rail to the top of the secondary suspension between the bogie's left and right side or the front and rear bogies. It is finally also the load distribution within a vehicle body as well as the flatness of the supporting surfaces, contacting the bogies.



Overview of influences on the bogie

Accordingly, the wheel load is also influenced by the evenness of the track, the train weight and load distribution as well as the aerodynamics in case of trains under higher speeds etc.

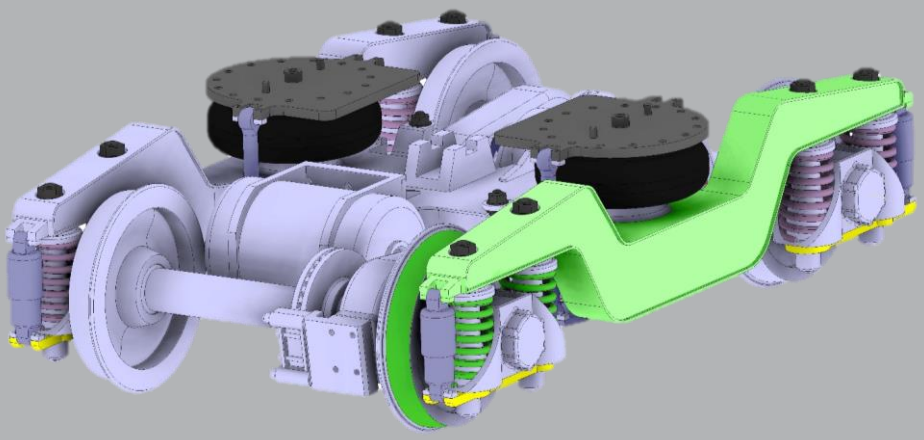
Components and correction methods:

Following, we describe more details regarding some vehicle components and possible correction methods.

The influence of different wheel diameter

There are different instruments for measuring the wheel diameters and profiles on a bogie or vehicle. If the diameters between left and right side wheel or amongst all 4 wheels are out of tolerance, EN 15313 < 0.3 mm, the wheels must then be re-profiled or exchanged. It is often several millimetres.

This reason may be explained in a simpler way, e.g.: The imagination of sitting on a four-legged chair, with one leg shorter than the others. While less weight is on the shorter leg, more is on the other three legs. Therefore, the weight (load) is not distributed equally to the other chair legs.



Wheel diameter, primary suspension, frame

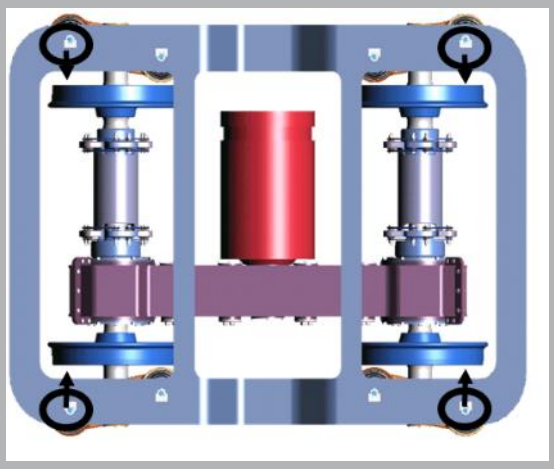
The primary suspension

Springs with different characteristics may have a negative influence to the wheel load. Therefore, during the heavy maintenance, the springs of the primary suspension should be checked by a spring test press. It is important to have springs with similar stiffness characteristics and heights within a bogie. The heights under load can be corrected with primary shim plates. Standards such as UIC 822, EN 13298 or EN 13913 are guidelines how and what is to be tested. Experience has shown that springs are often still in a good condition and can be reused, saving a lot of money.

Fully automatic spring testing

It is also known that helical springs in particular are moving sideways under increased vertical load. This is often called “chaise effect” or bowing of springs. If some primary springs under load are

moving in the same lateral direction, then the above described side force (Y) will increase automatically and the ratio of Q/Y becomes worse and the derailing safety is reduced. Under such circumstances, more wear on the wheels is the consequence.



Less wearing, neutralize side force thank testing of bowing angle

EN 13298 (2003) 5.2.3.3 specifies this effect. There are spring test presses available, enabling to determine the bowing direction of springs. The springs can then be marked and installed accordingly so that side forces are neutralized.

Frame check

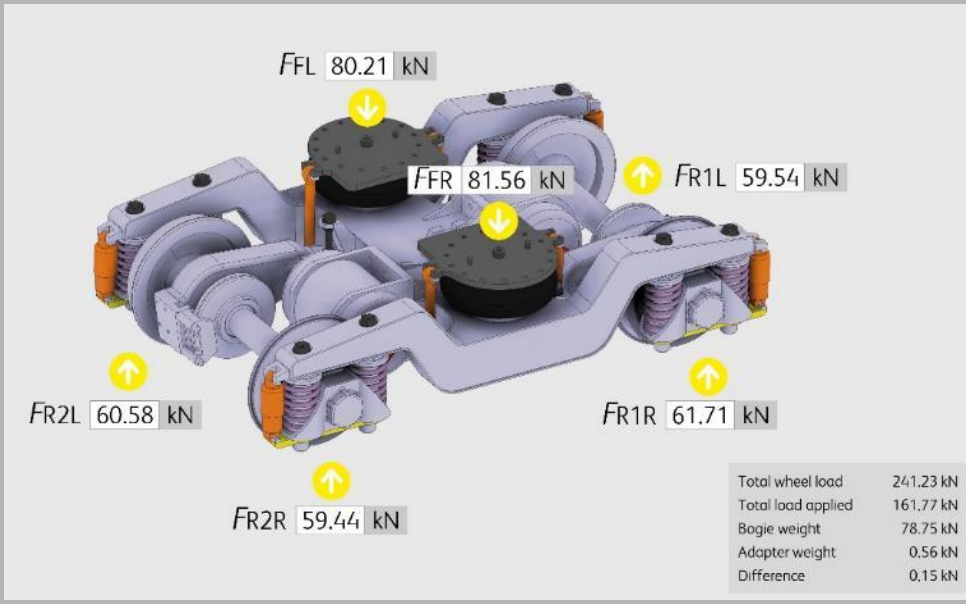
After several years of operation or after crashes, the geometry of a bogie frame should be checked. Possible criteria are the flatness and the positions of the primary spring guide shafts. The German State Railway “Deutsche Bahn DB” has issued special guidelines, considering also the DIN 27201-9 standards.

Function and quality control of bogies

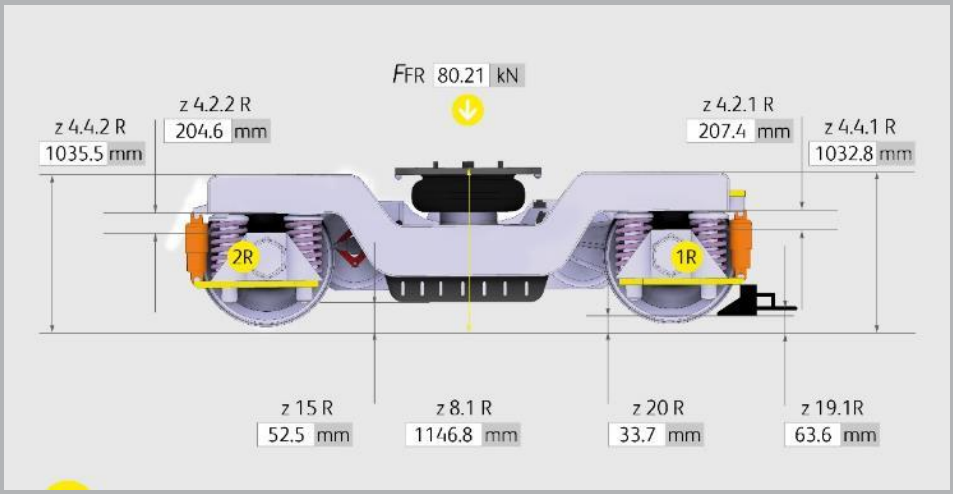
Nowadays, most bogie manufacturers and also many bogie maintenance workshops are equipped with bogie test benches. After assembling the bogie with all its components, the load of the specific vehicle body is simulated by PLC control onto the bogie.

Checking the load distribution and other adjustments on the bogie test stand

The distribution of the load between the wheels and each single wheel can now be determined. Possible corrections on the primary suspension with automatic calculated shim plates can be carried out. Additionally, the heights of the secondary suspension can be adjusted or corrected under simulated tare load. This is very important, in case of one bogie side with a big height difference, can even influence the wheel load of the bogie at the other end of the vehicle in a negative manner.

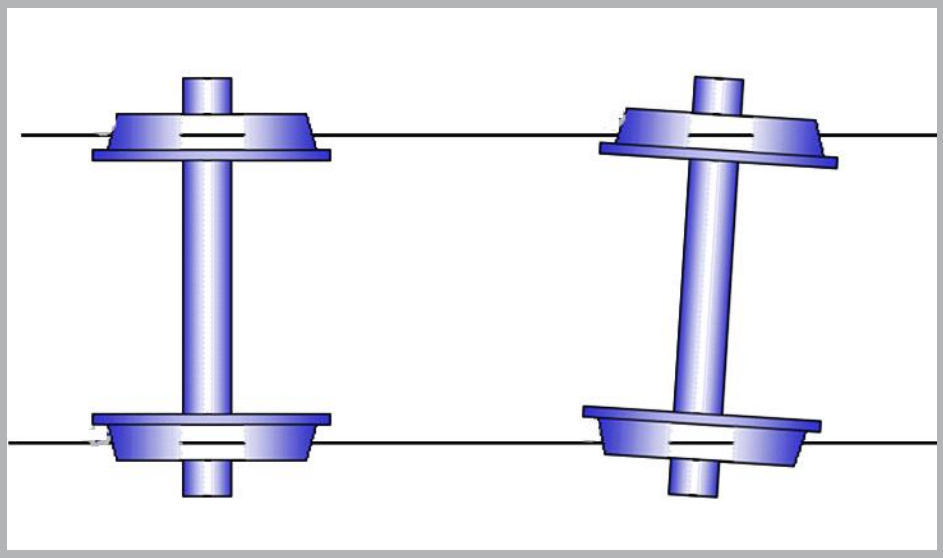


Under load simulation, it is also possible to adjust the correct heights of antenna, emergency brakes, coupling heights, etc. The DIN standard 25043-7 is a useful guideline, already considered in bogie workshops outside Europe. Regarding the wheel load the height of top of secondary suspension (bogie loading point) over T.O.R is be most important. Some rolling stock suppliers request in the their manuals < 2 mm, similar shall be between front an rear bogies.



Checking heights under simulated load

Sophisticated bogie test benches enable the measuring of axle distances, mainly the axle parallelism. This is a very important criteria which should be checked on bogies.



Un-parallel axles cause wearing and reduce the safety

It is doubtless, that a bogie with non-parallel axles as shown on this image, tends to always move in a curve, having increased lateral forces and less safety against derailing as a consequence. There will be more wheel wear, noise and vibration. The only method to recognize such a situation and making corrections is on the bogie test bench before the bogie leaves the workshop and causes damages.

The 4- corner weighing of the vehicle body

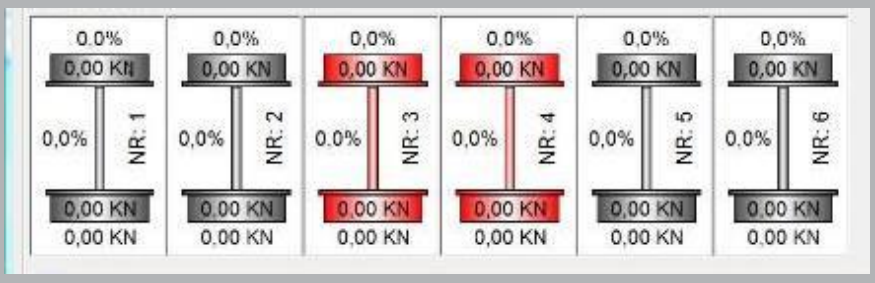
From where does the workshop know the correct load which shall be applied onto the bogie for testing? It is either from the rolling stock or the locomotive manufacturer , often to be found in the maintenance manual. In case of refurbished vehicle bodies or repairs after accidents, it is recommended to apply the method of 4-corner weighing described e.g. in the DIN 25043-4 standard. The result is the specific load forces which will be applied onto the bogie contact points. Another useful result of this test is to achieve the calculation of secondary shim plates to equalize the flatness of the contacting points to the bogie.

Determination of the load which the vehicle body applies onto the bogie

The final check of complete vehicles

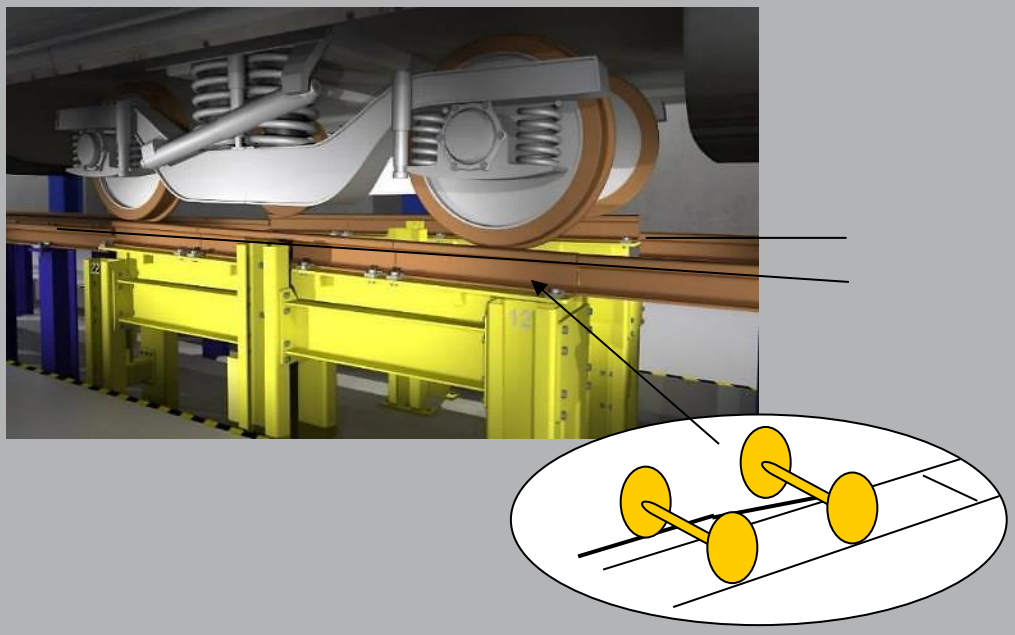
Before a vehicle leaves the workshop after overhaul or a preventive control, the balance of wheel loads of the complete vehicle shall be checked. This is the final check against derailing safety of the complete vehicle. There are several testing methods available such as mobile wheel weighing cells, stationary installed wheel weighing bridges. DIN 27201-5 offers the required calculation methods for the maximum differences of wheel loads within a vehicle. Maximum differences between wheels on a bogie < 5% are common .

Wheel load control in the workshop



Simulation of the situation at the end of curves or uneven tracks

A challenging situation for the wheel load occurs in case of uneven tracks or at the end of curves. The left front wheel on the left (in driving direction) according to the below photo, receives the smallest wheel load, so called unloading.



The EN standard 14363, chapter A.9.1. describes a method which allows to test the wheel load with twisting track, or in other words the simulation of an uneven track or end of a curve in a workshop. The unloading simulation and determination of the smallest wheel load can be tested on each single wheel either manually or better by an existing fully automatic test bench. If the difference between all bogie wheels, Δ Q/Q is out of tolerance, this then indicates that the vehicle is no longer safe against derailing on uneven tracks or at the end of curves. It should therefore undergo immediate maintenance before risking lives or damages. However, if a vehicle passes this test, it is safe against derailing and can continue operation and a scheduled and costly maintenance may be postponed. So this is a very good tool for condition based maintenance.

What are the challenges?

There are still many workshops or maintenance concepts which do not take enough care regarding the importance of the wheel load.

Safety, reliability and reduced life cycle costs must be one of the most important targets in workshops. Therefore the described practice should be applied and the necessary test equipment should be made available. The necessary investments should be budgeted – with the benefit of re-using springs, less wheel wearing and re-profiling, less unscheduled maintenance, etc. Consultants should implement those technologies into the design of workshops. In some countries authorities applied regulations regarding wheel loads etc. In many countries, they are still missing.

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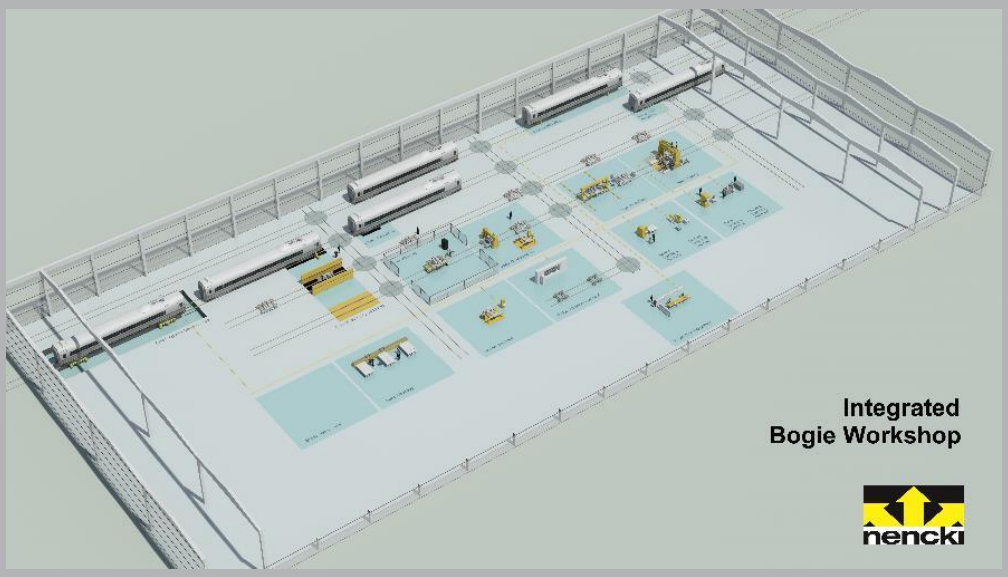

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