The community of independent consultants in mineral resources, mining, metal, and chemical industries in the CIS

INFOMINE
market research group

Railroad Wheels
Production, Market and Forecast in the CIS

8th Edition

Moscow
August, 2020

Content

List of Tables

List of Figures

Annotation

This report is the **Eighth** Edition of the study of the market of railroad wheels in the CIS countries.

The **purpose of research** is an analysis of the market of railroad wheels in the CIS.

The **object of the study** is railroad wheels.

Chronological scope of the study: 2000-2019; forecast - 2020-2025.

Geography of research: Russia and Ukraine - a comprehensive detailed analysis, other CIS countries - brief characteristics.

The report consists of **7** Sections, contains **189** pages, including **45** Tables, **50** Figures and **3** Appendices.

This work is a desk study. As information sources, we used data of Federal Service of State Statistics of Russia (Rosstat), the Statistics Agency of the Republic of Kazakhstan, the State Statistics Committee of Ukraine, the statistics of the Russian rail transportation, the Federal Customs Service of Russia, and Customs Committee of Ukraine.

Also, data of the sectoral and regional press, the annual and quarterly reports of companies, reports of issuers of securities, and the internet-sites of company-producers of railroad wheels, the railway car building plants and wagon repair plants were employed.

The **first chapter** provides a brief description of the global market for railway wheels.

The **second chapter** describes the technology of production of solid-rolled railway wheels and outlines the basic requirements for their quality

The **third chapter** is devoted to the production of solid-rolled railroad wheels in the CIS. It characterizes the current state of railway wheels producers in the CIS, presents data on the product types, and the dynamics of production in the period of 2000-2020 (6 months).

The **fourth chapter** describes foreign trade operations in Russia and Ukraine with railroad wheels for 2002-2019. This chapter analyzes data on volumes and destinations of foreign trade operations, and identifies the major suppliers and recipients of products.

The **fifth chapter** provides information about the dynamics of prices for railroad wheels on the domestic Russian market in 2000-2020 (6 months), and also the data on export and import prices on the product in Russia and Ukraine in 2003-2019.

The **sixth chapter** is devoted to consumption of solid-rolled railway wheels in Russia and Ukraine, it shows the production and consumption balances, gives the analysis of the wagon-building industry and the market of railcar-repair services, as well as a detailed description of the main consumers of railway wheels, and estimates the volumes of the wheel consumption by these enterprises.

The **seventh chapter** provides a forecast of the production and consumption of railway wheeled products in the period up to 2025.

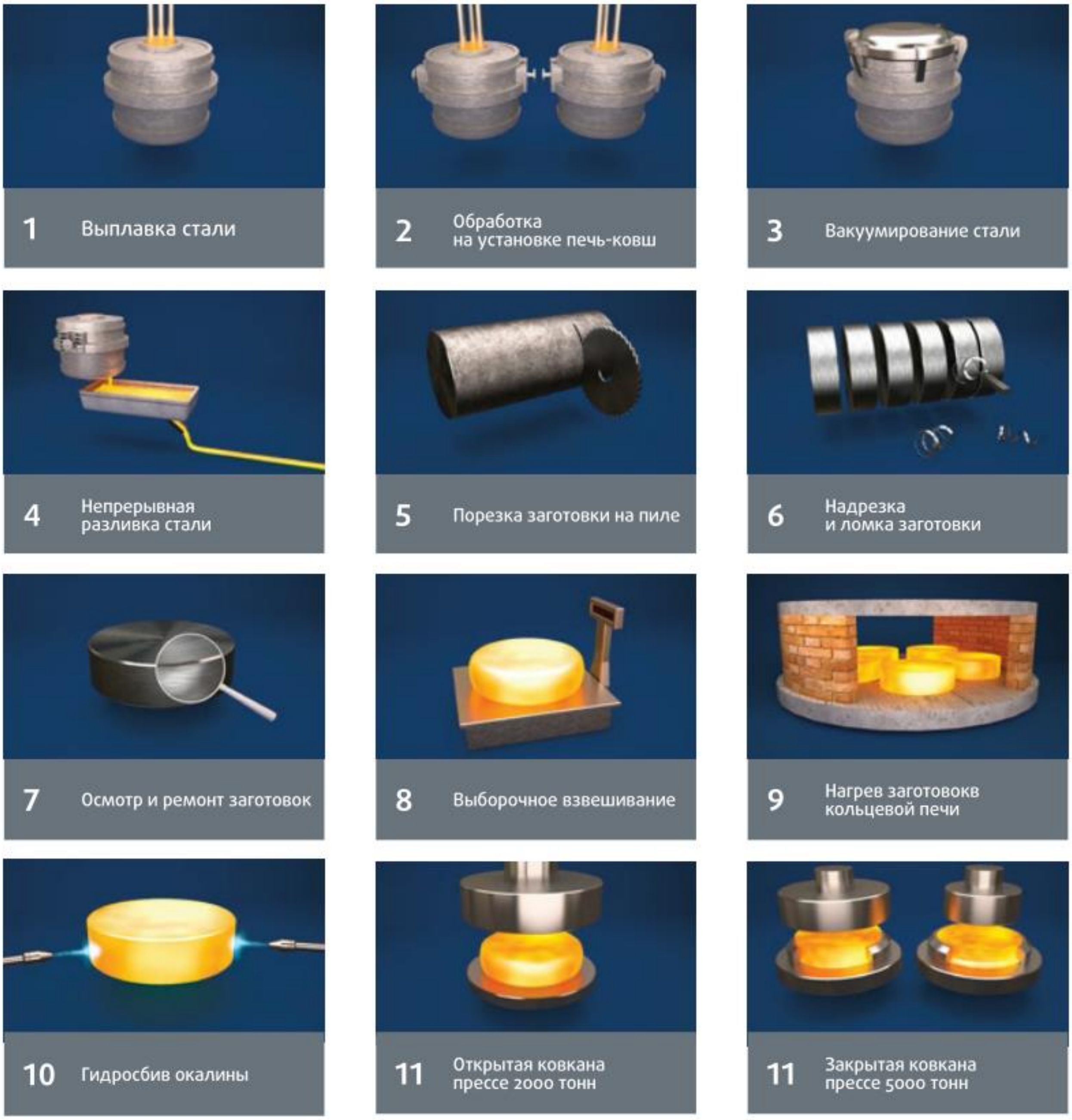
The **Appendices** to the report contain the technical characteristics of solid-rolled wheels produced in the Russian Federation, as well as contact information for manufacturers and major consumers of solid-rolled railway wheels in the CIS.

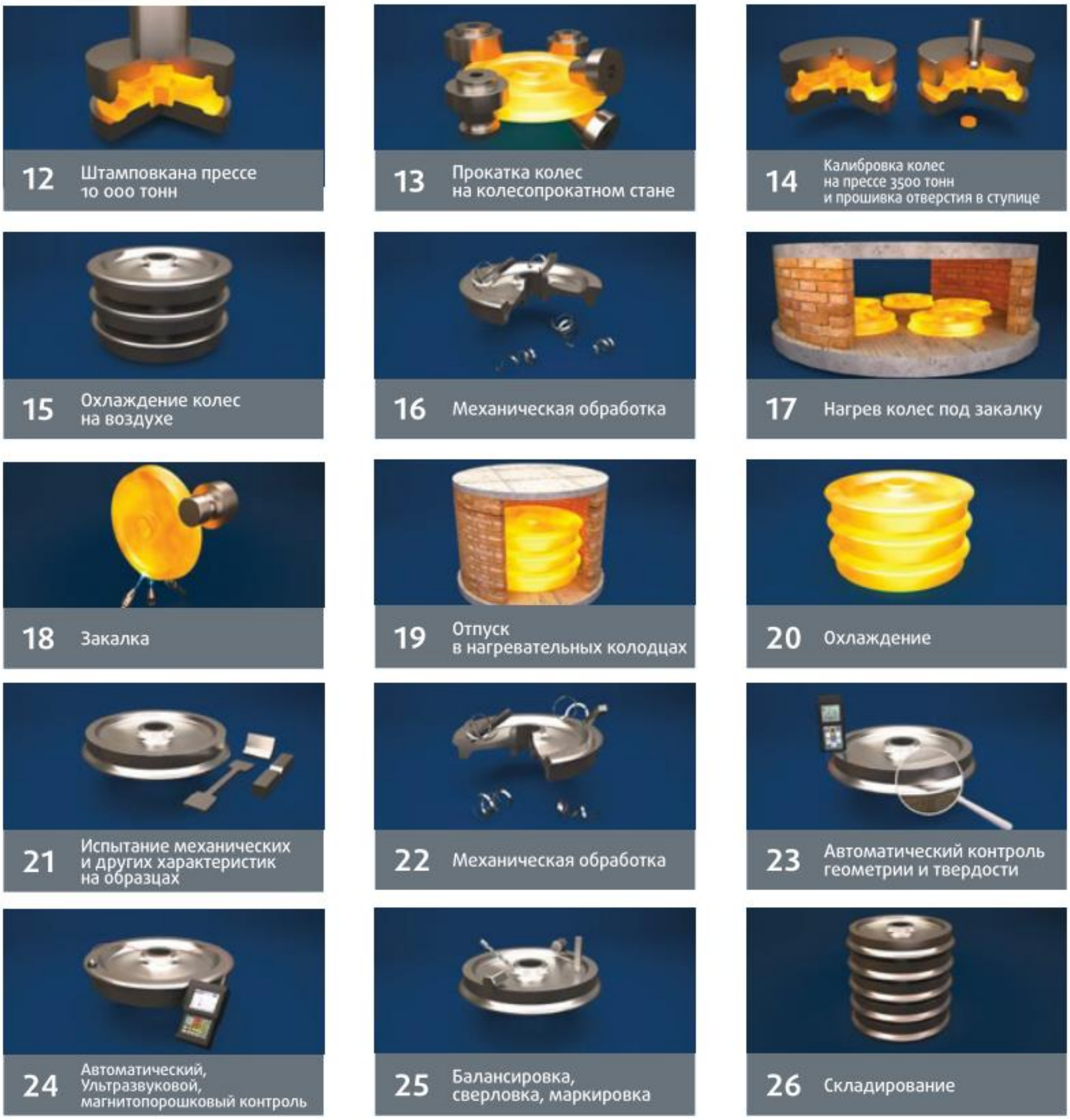
The **target audience** of the study is:

- participants in the market of railway wheels - manufacturers, consumers, traders;
- potential investors.

The proposed study claims the role of a **reference tool** for marketing services and specialists making managerial decisions working in the market of railway wheels.

Figure 1. Technological scheme of the railroad wheels production





Source: data of Interpipe Nizhniodniprovsk Pipe Rolling Plant

1 - Steel smelting; 2 Processing in a ladle furnace; 3 - Degassing of steel; 4 - Continuous casting; 5 - Cutting of the blank on the saw; 6 - Scoring and breaking blanks; 7 - Inspection and repair of blanks; 8 - Selective weighting; 9 - Heating blanks in the annular furnace; 10 - Descale sprays; 11 - Open forging on a press of 2,000 tons; 11 - Closed forging on a press of 5,000 tons; 12 - Stamping on a press of 10,000 tons; 13 - Rolling wheel on a wheel-mill; 14 - Calibration of the wheels on a press of 3,500 tons and piercing the hole in the hub; 15 - Air cooling of wheels; 16 - Machining; 17 - Heating of wheels for quenching; 18 - Thermohardening; 19 - Tempering in pit furnaces; 20 – Cooling; 21 - Testing of mechanical and other characteristics of samples; 22 - Machining; 23 - Automatic control of the geometry and hardness; 24 - Automatic, ultrasonic, magnetic particle inspection; 25 - Balancing, drilling, marking; 26 – Warehousing.

The *steel* for the production of wheels in Russia and Ukraine is smelted in open-hearth furnaces (Interpipe Nizhniodniprovsk Pipe Rolling Plant - until the end of 2011, AO Vyksa Metallurgical Plant - until early 2018), or by the oxygen converter process (OAO EVRAZ NTMK).

Since 2012, Nizhniodniprovsk Pipe Rolling Plant mastered the production of wheels using *a continuous casting billet,* obtained by an electric arc method.

AO Vyksa Metallurgical Plant switched to the use of continuous casting billets in 2018.

All three enterprises ***process the steel*** on the ***steel ladle complex*** and the ***degasser***, which significantly improves the qualitative characteristics of steel.

The ladles with a metal are supplied in sequence to the installation of a ladle furnace, for the shaping-up and refining the metal. The purging of steel with argon in the ladle provides a finished metal with a low content of sulfur and phosphorus, as well as the uniform distribution of other chemical elements. After the treatment in the ladle furnace, the steel is processed at the degasser for degassing.

The viscosity and ductility of the metal, obtained after such a treatment in combination with strength characteristics provide a high resistance of steel against the emergence and development of fatigue cracks, and against the brittle fracture of wheels.

Steel for production of wheels in EVRAZ NTMK is smelted in the converter shop, which is composed of the converter section with four 160-ton converters, the ladle treatment station, having 3 "ladle furnace" installations and 2 circulating degassers, and the section of the ***continuous steel casting*** having 4 CCM (continuous casting machines). The release of wheel blanks occurs on the 4-strand CCM #1 of the curved type for casting of round billets of steel, which was introduced in 1995. The cut round billets from CCM are used as the starting blanks for the production of wheels. The initial billets with a diameter of 430 mm are cut into pieces with Wagner saws.

The blanks are sent to the regenerative annular rotary hearth furnace for *heating*. Annular furnaces with the diameter of 28 m and 40 m and with a width of the rotating hearth, respectively, 3.0 and 4.4 m, are used for this operation. In this case 3 to 5 pieces are arranged on the hearth in one row. Then *the descaling* is carried out.

The next step is the ***pressing of wheels***. For this purpose, the workpiece first is treated on the 20 MN press, where it produces a loose pellet with a deformation of up to 30%, then the 50 MN press force is used, which performs the upsetting in a floating ring, the total degree of deformation is about 60-70%. After that the ring is centered, and a movable die produces a piercing of the central portion of the preform. This operation allows redistributing the metal between the central and peripheral areas, which provides the necessary thickness of the disc and forms the hub in a subsequent operation with a minimum of effort. This is possible with the bilateral flow of a metal from the neutral section to the hub and the rim during the punching process, which is carried out on the next unit-press with the force of 100 MN.

Then the ***wheels rolling*** is carried out on the ***solid wheel rolling mill***. The individual automatic adjustment of the position of the pressure rolled of the mill ensures an even distribution of the compressions and forces.

After the rolling, the wheels come to a double-acting press with the force of 35 MN. It bends the disc, *calibrates the wheel*, *pierces of the central hole* and makes the marking.

The ***heat treatment*** of wheels includes the anti-flaking annealing and strengthening, consisting of quenching and tempering.

The ***anti-flaking processing*** of wheels is carried out by an isothermal holding at a temperature optimal for the removal of hydrogen from a metal: +650°C.

The anti-flaking processing of wheels in AO Vyksa Metallurgical Plant and PAO Nizhniodniprovsk Pipe Rolling Plant is produced in continuous tunnel kilns of the length of 125 m with the hook conveyors, and a special machinery installs or removes wheels from hooks. OAO NTMK performs the isothermal exposure of wheels by 6 pieces in the pit furnaces, which are heated, as well as conveyor furnaces, by natural gas.

The isothermal exposure of wheels at 600-670ºC is carried out for three hours or more.

Then, after a hot deformation, wheels are subjected to the *supercooling* to a temperature of 400-550ºC to isolate the austenite and to complete the relevant structural transformations in steel, guaranteeing the hydrogen degassing from its solution in the iron. At such isothermal conditions the diffusion of hydrogen from the metal proceeds successfully, and the remaining hydrogen is more evenly distributed in the volume of the product.

Before quenching wheels are *heated* in a circular furnace to the temperature of 800-850ºC, and then are laid out on the installations for quenching.

The duration of the ***quenching*** is controlled depending on the carbon and manganese contents in the steel for 100-200 sec.

After the quenching, the wheels are collected in a stack of 6 pieces, and subjected to the air ***cooling*** for 30-40 minutes. This operation is necessary for improving the strength and ductility characteristics of a metal wheel.

Further wheels are ***tempered*** in pit electric furnaces for at least 2.5 hours at a temperature of 470-520ºC. The temperature is controlled depending on the chemical composition of the steel. After the ***machining***, the control and measurements of wheels are carried out, as well as the test of the mechanical characteristics on the samples.

2.2. Requirements to the quality of released railroad wheels

From 1 January 2012, a national standard of the Russian Federation is the interstate standard GOST 10791-2011 "Solid-rolled wheels. Technical conditions."

This document was adopted to replace GOST 9036-88 "Solid-rolled wheels. Construction and dimensions" and GOST 10791-2004 "Solid-rolled wheels. Specifications."

GOST 10791-2011 is the main regulatory document of the CIS countries. This GOST was adopted by the Interstate Council for Standardization, Metrology and Certification (protocol #46 of March 15, 2011). Azerbaijan, Armenia, Belarus, Kazakhstan, Kyrgyzstan, Moldova, RF, Tajikistan, Ukraine, and Uzbekistan voted for the adoption of the document.

GOST 10791-2011 was developed taking into account the main regulatory provisions of the European standard EN 13262:2009* (Railway applications. Wheelsets and bogies. Wheels. Product requirement) and the international standard ISO 1005-6:1994 (Railway rolling stock material - Part 6: Solid wheels for tractive and trailing stock; technical delivery conditions).

GOST 10791-2011 applies to solid-rolled wheels of UHL design according to GOST 15150 for wheel sets of locomotive-hauled freight and passenger cars, passenger, freight and shunting locomotives, motor and non-motor wheel sets of cars of electric and diesel trains, and special railway rolling stock.

This standard realizes for the Russian Federation requirements of technical regulations "On safety of railway rolling stock" and "On safety of high-speed rail" in relation to the solid-rolled wheels.

In accordance with GOST 10791-2011, the ***solid-rolled wheel*** is defined as the wheel made from a single piece by deformation when hot (a hot deformation) and consisting of a rim, a disc, and a hub.

GOST 10791-2011 defines such indicators as the accuracy of a wheel size, the surface finish, the level of mechanical properties and technological tests.

Solid-rolled wheels are classified as follows:

- By the brand of the steel (1, 2, T, L);
- By the manufacturing accuracy - into classes (1, 2);
- By the largest allowable internal defects detected by a ultrasonic inspection (USI), and by the level of contamination of steel by nonmetallic inclusions - into categories (A, V and S);
- By the additional types of treatment: a full profile machining (P), with balancing (B).

The scope of the wheels, based on the classification and, depending on the design of the wheels, the design maximum static load of the wheel pair on rails (the axial load) and the design speed of the rolling stock, is given in Table 1.

Table 1. Applications of solid-rolled wheels (GOST 10791-2011)

Maximum design axial load, kN (tons)	**Design speed of the railway rolling stock v_k, km/h**				**Design of wheels of railcars of locomotive traction, non-motorized cars of electric and diesel trains**
	$v_k \leq 120$	$120 < v_k < 160$	$160 < v_k \leq 200$	$v_k > 200$	
Wheels for the freight rolling stock					
230.5 (23.5)	2, T V, 2	-	-	-	A.1*
245.3 (25.0)	T V, 2	-	-	-	(A.2, A.3, A.4)**
264.9 (27.0)	T V, 2	-	-	-	(A.2, A.3, A.4)**
294.3 (30.0)	T * V, 2	-	-	-	(A.2, A.3, A.4)**
Wheels for the passenger rolling stock					
245.3 (25.0)	1, 2, L V, 2	1, 2, L V, 2	1, L * A, 1, P, B	L* A, 1, P, B	v160 km/h - (A.1, A.2, A.3, A.4)**, v_k >160 km/h - A.1**

* Allowed to use other brands of steel for special specifications.
Allowed to use other wheel designs for a special design documentation.
Notes:
1 The numerator shows the allowable grade of steel, the denominator - the category for internal defects detected by an ultrasonic testing, and contamination by nonmetallic inclusions, the accuracy class of manufacturing and types of the additional processing of wheels.
2 Upon request a full profile machining can be applied for wheels for the freight and passenger rolling stock with a design speed of 160 km/h.
3 Wheels for wheelset bogies of locomotives and motor cars of electric and diesel trains are subjected to structural balancing at speeds exceeding100 km/h.

Source: FSUE Standartinform

The level of physical and mechanical properties and performance characteristics of railway wheels is determined by the chemical composition of steel.

The starting material for the production of solid-rolled railroad wheel is carbon steel, the carbon content of which is in a wide range - from 0.4 to 0.7%, due to the operation of the wheels in different operating conditions, and their purpose.

For the heavily loaded freight rolling stock, wheels are made from the steel of high-carbon grades. The growing carbon content in steel increases the strength, wear resistance, it contributes to the fatigue endurance of wheels and the contact strength, but deteriorates the resistance against a thermal damage. Given the increase of speed of the rolling stock and, therefore, the increase in the thermal damage, the carbon content is lowered in the steel for wheels operating under severe braking conditions, particularly for high-speed trains.

The wheels are made of continuously casting billets or ingots. The steel is subjected to a secondary treatment and degassing. In accordance with GOST 10791-2011 the chemical composition of the steel according to the ladle analysis shall be as specified in Table 2.

Table 2. Chemical composition of steel of wheels (GOST 10791-2011)

Brand of steel	**Mass fraction of chemical elements, %**								
	carbon	manganese	silicon	vanadium	sulfur	phosphorus	chromium	nickel	copper
1	0.44-0.52	0.80-1.20	0.40-0.65	0.08-0.15	≤0.020	≤0.030	≤0.30	≤0.30	≤0.30
2	0.55-0.63	0.50-0.90	0.22-0.45	≤0.10	≤0.025	≤0.030	≤0.30	≤0.30	≤0.30
T	0.62-0.70	0.50-1.00	0.22-0.65	≤0.15	0.005-0.025	≤0.030	≤0.40	≤0.30	≤0.30
L	0.48-0.54	0.80-1.20	0.45-0.65	0.08-0.15	≤0.020	≤0.030	≤0.25	≤0.25	≤0.25
Note: the mass fraction of molybdenum should not exceed 0.08%, of titanium - 0.03%, of Nb - 0.05%									

Source: FSUE Standartinform

Wheels designed for use in passenger railcars of the locomotive traction, non-motorized railcars of electric and diesel trains, the special rolling stock with a design speed of over 160 km/h, as well as wheels, intended for use in the wheel pairs of locomotives and motorized railcars of electric and diesel trains with a design speed of over 100 km/h, are checked for a residual imbalance.

The mechanical properties of steel wheels, subjected to a hardening heat treatment, must correspond to ones specified in Table 3.

Table 3. Mechanical properties of steel for wheels (GOST 10791-2011)

Brand of steel	Ultimate rim strength σ_B, N/mm^2	Relative elongation of the rim δ, %	Contraction ratio of the rim ψ, %	Impact resistance KCU, J/cm^2			Hardness of a rim at a depth of 30 mm, HB
				rim	disc		
				At +20 °C	At +20 °C	At -60 °C	
		At least					
1	880-1080	12	21	30	30	20	≥248
2	910-1110	8	14	20	20	15	≥255
T	≥1020	9	16	18	18	15	≥320
L	≥930	12	21	30	30	20	280-320

Notes:
1 Hardness of a rim at the point *A* for the wheels made of steel of the brand T should be lower than the hardness at a depth of 30 mm from the tread surface by not less than 30 HB, and for the wheels of made of steel of brands 1, 2, and L - by at least 15 HB.
2 Hardness of a hub at a distance of 10 mm from the surface of its hole for the wheels made of steel of the brand T should be not more than 290 HB, for the wheels of steel of other brands there are no regulations.
3 The value of the ultimate disc strength must not exceed 90% of the actual value of the ultimate disc strength of the rim.

Source: FSUE Standartinform

Table 4. Mass of solid-rolled wheels (GOST 10791-2011)

Wheel	Diameter d of a hub hole, mm	Mass of a wheel*, kg
A.1	175_{-4}	398
	190_{-4}	392
A.2	190_{-4}	412
	205_{-4}	404
A.3	190_{-4}	409
	205_{-4}	401
A.4	190_{-4}	414
	205_{-4}	407

* The mass of the wheel is calculated from the average tolerances on the size and density of steel 7,850 kg/m^3.

Source: FSUE Standartinform

Manufacturers of solid-rolled wheels in the CIS have mastered the production of a wide range of railway wheels in accordance with international standards, in particular, for European railways (EN 13262:2004+A2:2011), American railways (AAR M-107/M-208:2018), etc. (see Appendix 1).

For reference:

The wheel pair consisting of the axle and attached thereto two wheels is the main element of chassis of the rolling stock

The locomotive wheelset consists of the axle, the wheel center, the tire and the pitch wheel.

The railcar wheelset consists of the axle, the solid-rolled wheel, and the tire.

The type of the wheelset is determined by the type of the axle and the diameter of its wheels. Excluding the motor and trailer railcars of electric multiple units, wagons of diesel trains, the main railway wagons wheelsets have one of the following types: RU-1050, RU-950, RU1-950, RU1SH-950. According to GOST for wheel sets, those sets that are designed for journal-boxes with rolling bearings, are made only of one of two types: RU1-950 or RU1SH-950.

These abbreviations stand for the following:

RU - Universal roller, bearings on the hub landing;

RU1 - Universal roller, bearings on a hot landing;

RU1SH - Universal roller, bearings on a hot landing with the bearing retention through the end plate.

The wheelset consists of the axle and two pressed-on wheels. The type of the wheelset is determined by the type of an axle and the wheel diameter. Axis types are as follows: R - Roller; U - Universal; 1 - for hot bearings on a landing; SH - a beaded mechanical fastening. For the wheelsets solid-rolled wheels are used, consisting of a rim, a disk and a hub.

A wheelset provides the direction of movement along the track, and takes all of the loads that are transferred from a railcar onto the tracks and back. The traffic safety depends to a large extent on the materials and design, the production technology, and a timely repair of wheelsets.

Equally important is the inspection of wheel pairs. The design of wheel pairs and their operational status have a huge impact on the smooth course of the train, the amount of forces that arise in the interaction of the railcar and the track, on the resistance to the movement.

As a rule, the wheelsets are made by a hard mounting the wheels on the axle by the pressing method. In this case the construction is very robust. The main defects of wheelsets are the following: the wear and loosening the tie of wheel sets, slides, undercut ridges, dents, cracks, a spalling of the gear, or of the wheel center, matchmarks, nicks. The unsatisfactory condition of wheelsets is a serious threat to security on the railway, so it is necessary to monitor the condition of parts and to repair wheelsets timely.

The wheelset shall comply with the following requirements: in conjunction with the journal-boxes to create the least resistance when driving; the elasticity ensures a noise reduction and mitigation of shocks; the wheelset, with a minimum weight, should be very strong.

Wheelsets are formed using special machines for processing axles and wheels; the overhead and jib cranes; hydraulic presses; stands providing the flaw detection of axles.

In order to ensure the traffic safety on the railways, there are state standards that set strict rules of OAO Russian Railways (RZhD) technical operations, which regulate the process of repair and inspection of wheel pairs, as well as the method of their manufacturing and operation. Different types of a periodic maintenance of wheelsets are set up - the overhaul, the depot, and the current.

As a rule, a major overhaul of wheelsets with a replacement of elements is made on the railcar-repair plants or in specialized wagon-wheel workshops.

The current and depot repairs are carried out in the railcar-repair depots.

For example, to correct a defect of the rolling surface, the boring of wheels and the restoration of its profile is carried out by the welding followed by a machining on the metal turning lathe or on the turning-milling machine.