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SOME FOREIGN SPECIFICATIONS FOR RAILWAY MATERIALS:

RAILS, WHEELS, AXLES, TIRES

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SOME FOREIGN SPECIFICATIONS FOR RAILWAY MATERIAL: RAILS, WHEELS, AXLES, TIRES

By G. K. Burgess and P. D. Merica

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I. INTRODUCTION

As a part of the Bureau's program relating to the determination of the causes of failure of railway materials, such as wheels, rails, axles, etc., as authorized by Congress, it was considered advisable to find out what is the European practice with respect to specifications for and tests of such types of material, together with any information available concerning the prevalence of accidents abroad caused by failure of railway equipment.

In pursuance of this idea the Department of State was asked to aid in the securing of the desired information, in accordance with the following letter of July 22, 1913:

The Department of Commerce, in view of an investigation by the Bureau of Standards of railway material in the United States, requests that the Governments of Austria-Hungary, Belgium, France, Germany, Great Britain, Holland, Italy, Russia, and Sweden be asked through the Department of State to furnish, if possible, information on the following matters:

The laws, regulations, or specifications now in force and when adopted covering the processes of manufacture and methods of inspecting and testing of wheels and axles for freight and passenger cars and locomotives, and what types and sizes of wheel and axle are used or permitted for the several classes of service; analogous

information concerning rails; statistics as to the number of derailments and their causes as apportioned among defective wheels, axles, rails, and other defective equipment or permanent way.

As a result of this inquiry the consuls general of the United States resident in the several countries mentioned took great pains to secure as complete data as possible; and their requests for information were cordially responded to by the several railway administrations, whether under governmental or private control.

The Bureau of Standards takes this opportunity of expressing its appreciation of the effective cooperation by the Department of State and of the foreign railway administrations; and it is hoped that the information thus obtained may be of some interest and service to the railways and manufacturers of railway material in the United States, in that it gives an opportunity to compare American and European practice for some of those portions of railway equipment which are most subject to the failures causing accidents.

There are also included some accident statistics which, however, are to be considered mainly as indicative of their relative frequency in the several countries, and as caused by failure of railway material. An exact comparison can not be made on account of different classifications and methods used in reporting accidents.

The discussion and comparison of the several types of foreign specifications and tests of rails, wheels, axles, and tires, treated by subjects, forms the main text of the report, while the detailed specifications and descriptions of tests are given by countries in the appendix.

The authors take this opportunity of expressing their appreciation of the aid rendered in the translation of the Italian specification to Mr. A. Fanti and in the translation of the Swedish specification to the Bureau of Foreign and Domestic Commerce.

II. SOME ACCIDENT STATISTICS

The data gathered relative to the number and causes of accidents are shown in Table 1, in which there is also included for comparison similar figures for the United States, culled mainly from the reports of the Interstate Commerce Commission. The foreign figures are evidently, in many cases, very incomplete, and the basis of computation is not a common one for the various countries, so that strictly exact numerical comparisons with the American figures can not be made. Nevertheless, there is sufficient information available in the table to draw some fairly trust-

worthy conclusions concerning the relative prevalence of accidents due to faulty equipment abroad and at home.

The number of failures would be expected to bear some relation to the density of traffic, both passenger and freight, unless there existed a marked difference in quality of material in going from one country to another.

The railroads of Great Britain and Ireland, for example, carried in one year over 3000 million passengers and 520 million tons of freight with only 24 derailments from all causes causing injury to persons. In these accidents 209 persons were injured, of which 13 were killed. For the same period in the United States there were carried a third as many passengers (1004 millions), but somewhat over three times the freight (1844 million tons), over 183 000 miles of track; but there were from 4000 to over 5700 derailments, in which 5000 to 7500 persons were injured.

In Table 1 are also given the number of derailments per million passengers carried and per thousand miles of track for the countries for which these data are available, namely, Austria, Germany, the United Kingdom, and the United States. This shows 26 times as many derailments per mile of track for the United States as for Great Britain and 3 times as many as for Germany, but only one-third the Austrian record. In terms of passengers carried, the Austrian and American derailments are not very different, but the American are nearly 600 times the British and 24 times the German. An inspection of the table shows also low accident or derailment figures for France, Russia, and Sweden, there being, for example, about one passenger injured, due to derailments, per two million carried in France as against 14 for the United States.

There appear to be but few foreign statistics available concerning the removal for defects of such railway materials as rails, wheels, and axles. Such statistics are of interest as giving a measure of quality of each type of material or equipment for the service intended.

Some data of this sort on rails are given in a series of articles by Fremont.[1] He says:

> Rail breakages are very frequent. In France it is calculated that there are from 2500 to 3000 per year. * * * In France the percentage of yearly breakages is about one per 2000 rails in service. * * * In 1898 there were 3223 rail breakages on the 33 674 km of railroads of Austria-Hungary, about one failure per 2000 rails; on the 88 135 km of German railroads there were 13 504 failures; that is, about one per 1350 rails.

[1] Le Genie Civil, vol. 59, 1911, p. 7.

He quotes from a report by M. Callon, 1910 (Minister of Public Works), showing that the number of such failures in proportion either to the total length of track or to the total number of rails in track is growing rapidly in France. Thus there were the following percentages of increase of failures:

Railroad	Per cent increase	Period
Midi	230–260	5 years, 1904–1908.
de l'Est	160–190	
d l'Ouest	40–50	
du Nord	4–20	4 years, 1904–1907.
d'Orleans	60–75	5 years, 1904–1908.
P. L. M.	10–20	4 years, 1904–1907.

Such data for the United States could perhaps be obtained from the records kept by the railroads, and, in fact, are available for rails in the reports of the American Railway Engineering Association, from which it appears that there were removed from the tracks in 1911 for defects 36 641 rails for 12 688 714 tons laid, and in 1912, 61 047 failed rails for 13 736 956 tons, or in 1912 there was a potential accident for 1 in about every 470 rails in the track in the United States, which possible accident was presumably prevented only by the track-inspection service of the railroads. That there were, nevertheless, 363 derailments caused by defective rails in 1912, 1255 caused by wheels, and a total of 5724 derailments in one year caused by defective equipment or track, points to the desirability of examining the question of the improvement of specifications and tests of at least some of the railway material, the failure of which may cause accidents.

It was with the object of putting the European practice in these matters before those in the United States interested in and responsible for railway matters that these foreign specifications have been secured. European practice is believed to be of interest for one reason, among others, that the foreign railway materials, such as rails, wheels, and axles, appear to perform the duty imposed upon them in a more adequate manner, generally speaking, than is the case in America.

TABLE 1

Statistics Concerning Derailments

Country	Year	Derailments on account of—				Total per year	Persons injured per year	Miles of track	Passengers carried per year in millions	Tonnage carried per year in million tons	Derailments	
		Rails	Wheels	Axles	Miscellaneous						Per 1000 miles of track.	Per million passengers
Austria	1912	[a] 56	[b] 86	.....	[c] 1301	1443	(d)	20 563	[e] 276	[e] 136	71	5.2
United Kingdom	1911	257	82	91	[f] 4187	[g] 4617	.....	23 200	3127	523	.....	.....
	1912	265	83	93	[f] 3909	[g] 4350	[h] 209	.....	.....	.....	.....	.....
	1912	[i] 1	[i] 4	.....	[i] 19	[i] 24	[j] 703	.....	.....	.....	[i] 1	[i] 0.008
France [k]	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Russia	1906	.....	.....	.....	.....	223	.....	.....	.....	.....	.....	.....
	1907	.....	.....	.....	.....	241	.....	.....	.....	.....	.....	.....
	1908	.....	.....	.....	.....	227	(d)	.....	.....	.....	.....	.....
	1909	.....	.....	.....	.....	197	.....	.....	.....	.....	.....	.....
Sweden	1910	44	.....	.....	.....	[g] 44	.....	.....	.....	.....	.....	.....
	1911	66	34	2	.....	[g] 102	.....	8677	[l] 18	[l] 11	.....	.....
	1911	[i] 0	[i] 2	[i] 0	.....	[i] 2	.....	.....	.....	.....	.....	.....
	(m)	[i] 0	[i] 0.8	[i] 1	.....	[i] 1.8	.....	.....	.....	.....	.....	.....
Germany	1911	[a] 53	7	13	233	306	(d)	38 747	[n] 1541	[n] 531	8	0.2
United States	1911	249	997	355	2448	[o] 4049	5148	183 000	1004	1844	[p] 26	[p] 4.7
	1912	363	1255	410	3696	[o] 5724	7541					
	1913	340	1223	474	2329	[o] 4366	6868					
	(q)	220	939	343	2350	[o] 3852	.....	.....	.....	.....	.....	.....

[a] Includes permanent way.
[b] Includes other defects of rolling stock.
[c] Includes signals, carelessness, etc.
[d] In 1908 there were 2855 passengers injured in Austria, Germany, and Russia combined.
[e] Figures relate to 1911.
[f] Includes over 2400 broken couplings.
[g] Total accidents whether causing derailment or not.
[h] From derailment (13 killed).
[i] Accidents causing injury to persons.
[j] Total injured on railways due to railway defects.
[k] For the 12-year period from 1895–1906 detailed data were not available in all particulars. However, in 1904 only 0.17 per million were injured by reason of derailments, and in 1906, 0.73 per million. During 4 years of this period there were no deaths due to railway accidents.
[l] Figures relate to 1909.
[m] Average for the 6 years 1906–1911.
[n] Figures relate to 1910.
[o] Accidents causing injury to persons or loss of property.
[p] Average of 1911, 1912, and 1913.
[q] Average for the 11 years 1902–1912.

III. DISCUSSION AND RÉSUMÉ OF SPECIFICATIONS

There are given in the appendix specifications for railway materials, rails, axles, tires, and wheels from the following countries: The United Kingdom, Italy, France, Belgium, Germany, Austria, Holland, and Sweden. It will be noticed that these specifications fall into groups, one group being formed by the United Kingdom; one by France, Italy, and Belgium; and one by Germany, Austria, Holland, and Sweden. The variations in the specifications within each group are less marked than those between groups.

1. AUTHORITY OF SPECIFICATIONS

The railways of the different countries of which specifications are given here are differently organized, and whereas in one case these specifications may be issued by the Government itself through its railway administration, in other cases the specifications are no concern whatever of the Government, but are drawn up and issued solely by the privately owned railroads.

In the United Kingdom the railroads are all privately owned and each railroad naturally issues its own specifications. Nevertheless, "approximately 60 per cent of the construction by railway companies conforms to the specifications published by the Engineering Standards Committee, a semiofficial organization supported by voluntary associations and by the Government; and when these specifications are not followed by the railroads, those issued by the latter conform more or less closely to them.[2]

In 1907 the railway clearing house drew up some specifications for the construction of "private owner's waggons," [3] and while these hold primarily for freight cars owned by private firms or individuals, "it is stated by a general manager of one of the English railways that these are adhered to generally by the railways in the construction of their own cars." [4]

In Italy the railroads are practically all owned and administered by the State and specifications drawn up and issued by the State Railway Administration.

In France the railways are privately owned, with the exception of the Western Railways and a southern line comprising the State Railway System, and specifications are issued by each of these

[2] Quotation from letter from Deputy Consul General Loop at London, 1913.
[3] The English term for freight car.
[4] Quotation from letter (1913) from Deputy Consul General Loop at London.

railways. Since 1901, however, much effort has been made to unify these specifications, such that with few exceptions there exist French standard or unified specifications for such equipment. These are published.[5]

Specifications of the four principal French railroad systems are given in the appendix.

The railroads of Belgium are practically all State railroads, and the specifications of the State Railway Administration are given in the appendix.

The railways of Germany are practically all State owned; that is, they are, for the most part, owned and operated by the various German States. Specifications issued for the Prussian and Prussian-Hessian railways are given in the appendix, together with those of the several associations, official or semiofficial, such as the Association of German Railway Administrations and the German State Railway Car Association.

The railways of Austria are also practically all State owned, and in the appendix are given the Austrian Government specifications for railway material.

In Holland the railways are all privately owned, and specifications as issued by four of the largest railway companies in Holland are given in the appendix.

About one-fourth of the Swedish railways are State owned. The specifications given in the appendix are issued by the Royal Administration of State Railways.

2. TYPES OF RAILS AND ROLLING STOCK

It is generally known that the service conditions to which rails, wheels, and axles are subjected in the United States are in many respects more severe than in the United Kingdom or on the Continent. The rolling stock is generally lighter abroad, although the tendency has been in recent years in the direction of heavier equipment; and the rails are practically as heavy as American rails, or, relative to the service, they are, in general, much heavier.

In Table 2 are given the weights of the types of rails used on the foreign railways at present.

[5] Cahiers des Charges des Compagnies de Chemins de Fer. Quai des Grand Augustins 49, Paris.

TABLE 2
Weights of Various Foreign Rail Types

Country and railway	Date	Weight of rail in pounds per yard	Weight of rail in kilograms per meter
United Kingdom (Engineering Standards Committee):			
Bullhead rails	.....	50–100	.....
Flat bottom rails	.....	50–100	.....
Italian State railways	.....	105	50.6
	.....	94	46.3
	.....	73	36.1
France:			
Eastern Railways	.....	94	46
Northern Railway	1900	92	.....
State Railways	.....	94	46.0
	.....	93	45.5
Paris, Lyon & Mediterranean Railways	1893	98	48
Belgium: State Railways	.....	82	39
	.....	116	57
Germany	1898	87	41.8
	1890	92	44.2
	1911	93.5	45
	1911	98.5	47.3
Austria: State Railways	1911	73	35
	1912	90	43
	1911	86	41.5
Holland: Netherlands Central Railway	1912	94	45.2
	1892	82	39.5
Sweden: State Railways	1896	83	40
	1899	70	33.6

It is very difficult to define in any way the severity of the service to which railway material is subjected, but some idea of it may be gained from a consideration of the dead weights and capacities of types of rolling stock.

In Table 3 is found a brief description of some types of foreign rolling stock. In some cases marked with an asterisk (*) the weights given are average values.

TABLE 3
Weights of Foreign Rolling Stock

Country	Locomotives		Passenger cars		Freight cars		
	Dead weight	Weight per axle	Dead weight	Weight per axle	Dead weight	Capacity	Maximum weight per axle
	Tons	Tons	Tons	Tons	Tons	Tons	Tons
United Kingdom	45–65	15–17	.....	.....	10–15	<*15	15
France	45–65	15–18	15	7	6–7	*13	.....
	[a] 50–92	11–18	36	8	10	15–18	15
	.....	.....	.....	.....	15–18	30–40	15
Germany	45–65	.....	.....	.....	10–15	*15.5	.....
Belgium	[a] 50–92	11–18	15	7	10	15–18	15
	.....	.....	36	8	15–18	30–40	15

[a] Ghent Exposition (1913).

A summary of the weights of axles and wheels is given in Table 4.

Often the size of the equipment, such as wheels or axles, is prescribed by setting an upper limit to the static stresses that may be developed in any part. For instance, the railroads of France prescribe generally, directly or indirectly, a maximum wheel load of from 16 100 to 16 800 pounds, while the German laws prescribe a maximum static stress of 10 000 pounds per square inch in the journal of freight-car axles and of 7900 pounds per square inch for passenger-car axles.

TABLE 4

Weights of Axles and Wheels, Freight and Passenger Cars

Country and railway	Date	Weight of axle		Date	Weight of wheel and tire	
		Pounds	Kilograms		Pounds	Kilograms
France: Eastern Railways	1912	564	254	1912	910	410
	1911	672	302	1911	910	410
	.....	764	345	1912	910	410
Austria: State Railways	.....	560	252	1911	910	410

3. RAILS

Specifications all call for steel rails, although chemically the kind of steel that is desired is generally not very definitely specified.

In the Table 5 is given a column showing what chemical specifications are in use, and it will be seen that in some cases even the carbon content is not specified. Certain characteristic items of the process of manufacture of rails are considered below with the various clauses concerning them.

Size of Ingot.—Several of the 12 sets of rail specifications give the size of the ingot from which the rails shall be rolled; these are those of the United Kingdom, the Italian State Railways, the Belgian State Railways, and the Holland Railway (Dutch).

Discard.—Most of the specifications call for a discard to be made after rolling. Those of the United Kingdom, the Northern Railway (France), the Paris, Lyon & Mediterranean Railways (France), the Belgian State Railways, and of the Holland Railway specify that enough discard be taken to insure soundness in the rail, while those of the Italian State Railways, the French State Railways, the Eastern Railways (France), and the Swedish State Railways require a definite amount of discard, which varies from 1.5 to 2.5 meters of the rail bar from the upper part of the ingot.

Gagging.—All of the specifications require that gradual application of the pressure be made in the process of cold straightening.

Finishing of the Rail Ends.—All of the specifications but those of the United Kingdom, the Swedish State Railways, and the Eastern and Northern Railways (French) state that the rail ends must be machine finished, milled or otherwise.

Tests and Taking of Test Specimens.—A synopsis is given in Table 5 showing what tests are required for rails and how many must be made for a given lot.

Ultimate strengths varying from 80 000 pounds per square inch to 112 000 pounds per square inch are called for, with elongations of from 15 to 8 per cent. In some cases the values for the ultimate strength and the elongation must stand in some prescribed relation. In only one case is the yield point specified.

The bending test required is a static one and generally consists of two parts. At first a span of the rail is loaded at the center with a load which is not supposed to permanently bend the rail. Thereupon a load is applied under which it yields, but only very slightly, the maximum amount of deflection at the center being prescribed.

The drop test is carried out with a drop testing machine, which consists of an anvil weighing 10 000 kg embedded in a mass of masonry 1 m deep and 3 m^2 in area. The weight of the tup varies from 600 to 2000 pounds when specified at all; its weight is not specified in the German, Austrian, and Dutch specifications. The British, Eastern Railways (French), Paris, Lyon & Mediterranean Railways (French), and the Belgian specifications call for one heavy blow, whereas the others, particularly those of the German group, call for numerous lighter blows.

TABLE 5

Synopsis of Rail Tests and Chemical Compositions Specified

Country and railway	Chemical elements specified	Tensile test	Bending test	Impact or drop test
United Kingdom (Engineering Standards Committee):				
Bull head	C, Mn, Si, P, S	1 per 100 tons		1 per 200 rails; 1 per heat.
Flat bottom	C, Mn, Si, P, S	do		Do.
Italy: State Railways.[a]	P, S	1 per group of 200 rails.[b]	1 per group of 200 rails.	1 per heat.

[a] Corrosion tests on specimens from every group of 200 rails are also prescribed.

[b] Here and elsewhere in this table the grouping is such that each group contains one or more heats.

TABLE 5—Continued

Country and railway	Chemical elements specified	Tensile test	Bending test	Impact or drop test
France:				
Eastern Railways.	.....	1 per group of 100 rails.	1 per group of 100 rails.	1 per group of 100 rails.
Northern Railway.	.....	.....do.....	.....do.....	1 preliminary test per heat; 1 per group of 100 rails.
State Railways.	C, P.....	1 per 200 rails	1 per 200 rails.....	1 preliminary test per heat; 1 per 200 rails.
Paris, Lyon & Mediterranean Railways.	C.....	3 per group of 300 tons.	3 per group of 300 tons.	1 preliminary test per heat; 3 per group of 300 tons.
Belgium: State Railways.	.....	1 per group of from 100 to 200 rails.	1 per group of from 100 to 200 rails.	1 per heat;[a] 1 per group of 100 to 200 rails.
Germany: Prussian-Hessian State Railways.[b]	.....	1 per group of 200 rails.	.....	1 per group of 200 rails.
Austria: State Railways.[b]	.....	.....do.....	1 per group of 200 rails.	Do.
Holland:				
North Brabant Railway.	.....	.....do.....	.....	Do.
Netherlands Central Railway.	.....	.....do.....	.....	Do.
Holland Railway.	.....	1 per group of 100 rails.	1 per group of 100 rails.	1 per group of 100 rails.
Sweden: State Railways.[b]	P.....	A tensile test is required.	.....	A drop test is required in each heat.

[a] This specimen is taken from upper end of ingot.
[b] A hardness (ball) test is required on 1 of every 200 rails.

4. AXLES

Axles are to be of steel, of which the chemical composition is not further specified, except that references are made to the phosphorus content and to the nickel content required for locomotive crank axles. Very often the cross section of the ingot from which the axle is forged is specified to be four or five times that of the finished axle. Usually axles are required to be annealed after forging, and locomotive axles quenched and drawn.

In the Table 6 is given a synopsis of the tests required for axles.

The tensile strength required varies from 64 000 pounds per square inch to 95 000 pounds per square inch and the elongation from 15 to 25 per cent. In a few cases the yield point is required to be from 40 to 50 per cent of the ultimate strength.

The drop test is carried out both on the body of the axle and on the journal; the weight of the hammer used is specified (2000

pounds) in only two or three cases. In all but one set of specifications several (5 to 8) blows are struck, and the axle is generally turned so that the blows are not all applied in the same direction.

In many cases a fracture test is required. For this purpose an axle of excess length is required, which is notched at one end and the excess length broken off in the drop testing machine. The fracture must be sound and homogeneous.

TABLE 6

Synopsis of Tests of Axles

Country and railway	Chemical elements specified	Tensile test	Drop test—journal	Drop test—body of axle	Miscellaneous tests
United Kingdom (Engineering Standards Committee).	S, P	1 per 50 [a]		1 per 50 [b]	
France:					
Eastern Railways	P [c]	do.[a]	1 per 50[a]	do.[a]	Fracture test on each axle.
Northern Railway	P [c]	do.[a]	do.[a]	do.[a]	Do.
Paris, Lyon & Mediterranean Railways.	P [c]	do.[a]	do.[a]	do.[a]	Do.
Belgium: State Railways		([a])		do	
Germany: Prussian Railways	([d])	1 per 50		do	
Austria: State Railways	P	1 per heat		1 per heat	
Holland:					
North Brabant Railway		do		do	
State Railways		1 per heat [a]		do	Bending test.[a]
Holland Railway	([d])	1 per 50			
Sweden: State Railways	([d])	2 per 50		1 per 50	

[a] For locomotive crank axles no tests on the whole axle are required, but from each axle small specimens are taken (from an excess length) upon which impact and tensile tests are carried out.

[b] This is a fatigue drop test for crank axles made on small specimens from axle and may have as an alternative a cold-bend test.

[c] The use of pig iron containing more than 0.1 per cent P is forbidden.

[d] Nickel or chromium content specified for crank axles.

5. WHEELS AND TIRES

Many types of car and locomotive wheels are used abroad. The chilled cast-iron wheel, the type most used in the United States for freight service, is not generally used, and is very seldom mentioned in foreign wheel specifications. It is allowed on German and Swedish railways for unbraked wheels on freight cars which run at limited speeds (45 km, or 28 miles, per hour). The type most generally used is a combination of wheel center of steel, cast or rolled, or wrought iron, with a shrunk-on steel tire. The wheel centers may be of the plate or of the ribbed or spoke type.

6. TIRES

The tires are to be of steel, forged and rolled into the desired shape. The Table 7 gives a synopsis of the tests required for tires.

TABLE 7

Synopsis of Tests of Tires

Country and railway	Chemical elements specified	Tensile test	Drop test	Hydraulic flattening test	Miscellaneous tests
United Kingdom (Engineering Standards Committee):					
Locomotive tires	P, S[a]	1 per 50 or 1 per heat.	1 per 50 or 1 per cast.		1 drop test on each tire.[b]
Passenger and freight-car tires.	P, S	1 per cast of 50.	1 per cast of 50.		Do.[b]
France: Eastern Railways[c]	P[d] / 1 per heat	1 per heat	1 per heat [e]	1 per heat.	
Belgium: State Railways		Required *f*	do. *g*	Required *f*.	
Germany: Prussian State Railways.		1 per 50	1 per 50		
Austria: State Railways	P	1 per heat	1 per heat		
Holland:					
North Brabant Railway		do	do		
State Railways		1 per heat	do		
Holland Railway	P	do			
Sweden: State Railways		1 per 50	1 per 50		

[a] Also specified without analysis.
[b] The tire is let fall onto an anvil.
[c] The same data applies to the Paris, Lyon & Mediterranean.
[d] The use of pig iron containing more than 0.1 per cent is forbidden.
[e] For type (D) only.
[f] These are alternative to *g*.
[g] See *f*.

In the tensile test ultimate strengths are required, varying from 85 000 to 124 000 pounds per square inch, and elongations, from 8 to 18 per cent.

Two types of drop test are required. In the first, required in British specifications, each tire is dropped upon a rail fastened in an iron block. In the second type, required by all of the specifications, a fall hammer is used, the tire being supported on a block with its plane vertical. It is in some cases required merely that the tire not fracture or fissure under repeated blows of given energy, but in other cases (German and Austrian railways) it must be possible to flatten the tire by 12 per cent without any cracks appearing. The weight of the fall hammer is usually about 2000 pounds and the blows of about 20 000 foot-pounds of energy.

A static flattening test is also required in several cases. The amount by which the diameter of the tire is required to be reduced without failing is generally about 17 per cent.

7. WHEEL CENTERS

Wheel centers are made of forged steel, cast steel, or wrought iron. They are generally required to be annealed after being cast or forged.

The Table 8 gives a synopsis of the tests required for wheel centers for the various railways.

TABLE 8

Synopsis of Tests of Wheels

Country, railway, etc.	Material	Chemical elements specified	Bending test	Hub-expanding test	Equilibrium test	Tensile test	Drop test	Miscellaneous test
United Kingdom: Engineering Standards Committee.[b]	Cast steel	P. S.				1 per heat	Each wheel center.[c]	1 bending test[a] from each wheel center.
France:								
Eastern Railways—								
Plate wheel centers	Wrought iron / Steel	P / 1 analysis per heat.	1 per 100 W	1 per 100 W	Each wheel			
Cast wheel centers	Cast steel	P[d]	do	do.[e]	do.[e]	1 per heat	1 per heat	
Northern Railways [f]—								
Plate wheel centers	Wrought iron / Steel	P / 1 analysis per heat.	do	do	do			
Ribbed, spoked wheels	Wrought iron / Steel		do	do	do			Weldability, quench, and bending on small specimens.[g]
Cast wheel centers	Cast steel	(d)	do	do.[e]	do.[e]	1 per heat	1 per heat	
Belgium: State Railways	Wrought iron / Cast steel				Required	Tensile test is required.		
Germany: Prussian State Railways	Cast steel			1 per 50		1 per 50		
	Soft steel			do		do		
	Wrought iron				Required	1 per 50 W		
Austria: State Railways	Cast steel	1 analysis per heat.			Each pair	2 per heat	Each wheel[b]	
	Forged soft steel.				do	Required (1 per heat).	1 per heat	

Holland:								
North Brabant Railway[h]	Cast steel							
	Soft steel						Required	
State Railways	Wrought iron				1 per 50 W	Each pair	3 per 50 W	
Holland Railway	Cast steel					do	1 per 100 W	1 per 100 W.
Sweden: State Railways	Steel							

[a] This bending test is made on a small cast on specimen and not on the whole wheel center.
[b] A "ringing" test is required.
[c] The wheel center is dropped upon an anvil.
[d] The pig iron may contain not more than 0.1 per cent P.
[e] For simple wheels only.
[f] The data here shown apply also to the State Railways and the Paris, Lyon & Mediterranean Railways.
[g] For steel wheels only.
[h] Same data apply also to the Netherlands Central Railway.

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In the tensile test values of the ultimate strength are required varying from 52 000 to 91 000 pounds per square inch and values of the elongation from 15 to 20 per cent.

Each wheel center must be equilibrated, and a limit is set upon the amount of variation from the state of being perfectly centered.

In the transverse bending test the wheel center is supported flat at the rim, and pressure is applied at the hub parallel to the axis of the wheel; the wheel must allow of the hub being lowered by about 4 per cent of the diameter of the wheel rim.

In the hub-expanding test mandrels with a 1/100 taper or greater are introduced into the bore of the hub until one end has been expanded by about 5 per cent. This test must be passed without any fissuring at the hub.

There are two types of drop test applied; in one the wheel center itself is dropped upon an anvil; in the other, which is carried out on test pieces from the wheel center, a fall hammer is used.

The Austrian specifications require that the bending test be made by impact.

8. GUARANTIES FOR MATERIALS

Service guaranties are required in several specifications for all of these materials. For example, rails are often required to be guaranteed against failure, which can be considered as due to the manufacture or material for a period of six years. Table 9, giving a summary of these guaranties required, is shown below:

TABLE 9

Summary of Service Guaranties Required on Wheels, Axles, Tires, and Rails

Country and railway	Rails	Axles		Tires	Wheels
		Kilometers	Miles		
France:	Years			Years	Years
Eastern Railways	6				
Northern Railway	6	[a] 80 000 [b] 50 000 [c] 100 000	50 000 31 000 62 000		
Belgium		(d)	(d)	3	2
Germany	5				[e] 3
Austria	5				4
Holland	5	[f] 165 000	103 000	3	3

[a] For carriages and cars.
[b] In a period of 3 years.
[c] In a period of 4 years.
[d] Axles guaranteed for a period of 3 years.
[e] Applies tof reight cars.
[f] For crank axles.

9. CONCLUSION

In conclusion, a few points of general practice may be touched upon.

It is noticed that almost without exception the foreign specifications cited rely upon physical tests alone rather than upon chemical analyses or both chemical analysis and physical tests for their information concerning the various materials. Only phosphorus and occasionally sulphur seem to have engaged the attention of those drawing up the specifications. The physical tests always include stringent toughness or brittleness tests, which of course somewhat lessen the necessity of chemical analyses.

The specifications generally require that the manufacture of the articles and materials be under the surveillance of the inspecting agents and that the latter must have free access to the shops and plants of the manufacturers at all times during the manufacture of the articles in question.[6]

The practice in regard to indicating the method of manufacture is not uniform. In some cases (e. g., in Germany) this is almost entirely left to the manufacturer, who must, however, state in his bids what method will be used. In many cases open-hearth steel is specified, particularly for axles; in others both Bessemer and open-hearth material is allowed, as, for example, rails. In some cases nothing is mentioned regarding the method of manufacture of the material.

In most cases the mode of manufacture of the article is given in general details. For example, it may be specified that a wheel center shall be of cast steel, or of forged or rolled steel, afterwards annealed.

WASHINGTON, June 17, 1915.

[6] Such clauses are often found not in the particular specifications relating to the several articles, but in general ones of general applicability—e. g., Austrian specifications.

APPENDIX

SPECIFICATIONS FOR RAILWAY MATERIAL

[NOTE.—In the following specifications there have been some differences of practice with respect to omissions of the original texts.

If a specification is not marked with the asterisk (*) or with the dagger (†), it signifies that this specification is reproduced in full except where omission is noted in parenthesis with reference to the subject of the clauses of which omission was made.

A specification or set of regulations marked with the asterisk (*) is not in general fully reproduced; only those features have been selected which are of interest for the present purpose, and the text is in many cases paraphrased.

Specifications marked with the dagger (†) are complete as far as concerns the articles with which the present paper is concerned, namely, rails, axles, wheels, and tires, but clauses dealing wholly with other articles are omitted without mention being made of the omission.

The Bureau will be glad to fill in omissions in the specifications to interested parties by correspondence.]

CONTENTS

UNITED KINGDOM

ENGINEERING STANDARDS COMMITTEE

BRITISH STANDARD SPECIFICATION AND SECTIONS OF FLAT-BOTTOM RAILWAY RAILS (REVISED JULY, 1909)

1. **Chemical Composition.**—The steel for the rails shall be of the best quality made by the Bessemer, Siemens-Martin, or other process, as may be approved by the engineer (or by the purchaser).

The rails shall show on analysis that in chemical composition they conform to the following limits:

Carbon, from 0.35 to 0.50 per cent.
Manganese, from 0.70 to 1 per cent.
Silicon not to exceed 0.10 per cent.
Phosphorus not to exceed 0.07 per cent.
Sulphur not to exceed 0.07 per cent.

2. **Chemical Analysis.**—The manufacturer shall make and furnish to the representative of the engineer (or of the purchaser) carbon and phosphorus determinations of each cast.

A complete chemical analysis, representing the average of the other elements contained in the steel, shall be similarly given for each rolling. Such complete analysis shall be made from drillings taken from the rail or from the tensile test piece or pieces. When the rolling exceeds 200 tons, an additional complete analysis shall be made for each 200 tons or part thereof.

Should the engineer (or the purchaser) desire to make independent chemical determinations, the necessary specimens and samples shall be furnished by the manufacturer. For this purpose not more than two rails in every 100 tons manufactured shall be selected by the representative of the engineer (or of the purchaser) and drillings taken with a drill of 2 inches diameter from the top of the head of the rail unless otherwise specified by him; and if, upon being subjected to the specified tests, either fail to comply therewith, then all the rails in the cast of which the test pieces form a part may be rejected.

The representative of the engineer (or of the purchaser) may then take similar samples from a further two rails out of the same 100 tons, and should either fail to comply with the specified analysis the whole 100 tons may be rejected.

In case of difference between the engineer (or between the purchaser) and the manufacturer as to the accuracy of an analysis, either party shall have the right to have samples of the steel analyzed by an independent metallurgist, to be mutually agreed upon. The expenses attendant upon such independent analysis shall be borne by the party adjudged to be in the wrong.

3. **Manufacture.**—Each rail shall be made from an ingot not less than 12 inches square at the smaller end and 14 inches square at the larger end, which must be cogged down into blooms, and have sufficient crop then sheared from each end to insure soundness.

All straightening shall be done by pressure and not by hammering.

4. **Permissible Variation in Weight.**—A rolling margin of one-half per cent under to one-half per cent above the calculated weight will be permitted, but the calculated weight only will be paid for.

6. Templates.—Before the general manufacture of the rails is commenced the manufacturer shall, if required by the engineer (or by the purchaser), supply two sets of templates, internal and external, of approved material, for each "B. S." section of rail.

Each template shall be suitably engraved with the purchaser's name, the number of the "B. S." section (being the nominal weight of the rail in pounds per yard), the manufacturer's name and address, and the date of the contract.

These templates shall be submitted to the engineer (or to the purchaser) for his approval, and at the commencement of rolling the engineer will have a competent person present to approve of the section.

7. Rails to Conform to Templates.—Each section of rail shall be accurately rolled to its respective template.

8. Rails to be Free from Defects.—The whole of the rails shall be of uniform section throughout, true to templates, perfectly sound and straight, and free from splits, cracks, burrs, and defects of every kind.

9. Length of Rails for Straight Line.—A quantity of short lengths will be taken in such lengths and quantities as may be ordered by the engineer (or by the purchaser), provided that these short lengths are cut down from longer lengths found to be defective at the ends only, and that the total quantity taken does not exceed 7½ per cent of the contract.

10. Permissible Variation in Length.—The rails shall be the specified length at a temperature of 60° F. No rail will be accepted which is more than three-sixteenths of an inch above or below the length specified, whether for straight or curved lines.

11. Rails of Special Length for Matching in Curved Line.—When required by the engineer (or by the purchaser) rails are to be supplied from 1 to 6 inches shorter or longer than the normal specified lengths, and these special lengths are to have about 1 foot at each end painted with such colors as may be ordered.

13. Branding.—The brand shall be rolled on the web of each rail to show that the rail is of British standard section and made under the conditions of this specification; the number of the "B. S." section (being the nominal weight of the rail in pounds per yard), the process [7] by which the rails have been manufactured, the manufacturer's name, initials, or other recognized mark, and the month and year of manufacture shall also be rolled, in letters three-quarters of an inch in size, on one side of the web of each rail—e. g., B. S. 95- B. A.[7] ..... 4.04—and the number of the cast from which it has been rolled shall be stamped on the end of each rail in half-inch block figures.

14. Impact Test.—From each cast a piece of rail (which may be a crop end) shall be selected by the representative of the engineer (or of the purchaser) and stamped with his mark and the number of the cast. From this a piece 5 feet long shall be cut which shall be placed in a horizontal position, with the head uppermost, upon two iron or steel supports resting on a solid foundation, the upper surfaces of the supports being curved to a radius of 3 inches. The test shall comprise one blow, delivered midway between the bearings, from a falling iron weight or tup, the striking face of which shall be rounded to a radius of not more than 5 inches. The weight of the tup, the span of the test piece between the centers of the bearings, and the height of the drop for the various sections of rails shall be as tabulated below. The blow must be sustained without fracture. In addition to the above test the representative of the engineer (or of the purchaser) shall select one finished rail from every 200 offered, and a piece 5 feet in length cut from this rail shall be similarly tested as specified above.

[7] The following abbreviations are recommended: S. A., Siemens-Martin acid; S. B., Siemens-Martin basic; B. A., Bessemer acid; B. B., Bessemer basic.

B. S. section and nominal weight of rails per yard in pounds	Falling weight test		
	Weight of tup	Centers of bearings	Drop
	Cwts	Feet	Feet
20	5	3	8
25	5	3	9
30	10	3	10
35	10	3	12½
40	10	3	15
45	15	3	15
50	15	3	15
55	15	3	17½
60	20	3	20
65	20	3	20
70	20	3½	20
75	20	3½	20
80	20	3½	22
85	20	3½	24
90	20	3½	26
95	20	3½	28
100	20	3½	30

Should the length cut from the selected rail fail to comply with the test specified for its weight, two other rails from the same cast will be selected and similar lengths cut and tested, and the acceptance or rejection of the cast will be decided by the result of the three tests, so that if two of the rails selected fail to comply with the test the entire cast will be rejected.

15. Tensile Test.—From each 100 tons of rails the manufacturer shall (if required by the representative of the engineer or of the purchaser) cut a test piece from any rail selected as a sample rail, such test piece to be stamped to correspond with the sample rail. It shall then be placed in a testing machine of approved pattern, and shall have an ultimate tensile strength of not less than 40 tons per square inch nor more than 48 tons per square inch, with an elongation of not less than 15 per cent upon the standard test pieces C or D (see sketch, p. 47). Should the test piece fail to fulfill these conditions, the representative of the engineer (or of the purchaser) may require the manufacturer to test two other rails from the same cast in the same manner, and the acceptance or rejection of the cast shall be decided by the result of the three tests, so that if two of the three rails selected fail to comply with the test the entire cast will be rejected.

The representative of the engineer (or of the purchaser) may then take similar test pieces from a further two rails out of the same 100 tons, and should either fail to comply with the test the whole 100 tons may be rejected.

Should the engineer (or the purchaser) desire to have independent tests made, the manufacturer shall provide the necessary test pieces, viz, two for every 200 tons, properly shaped and prepared.

16. Holes in Rails.—The holes for fishbolts shall be drilled through the web from the solid at each end of the rails of the sizes and in the position shown in the British standard specification for fishplates for flat-bottom rails or on a drawing to be supplied by the engineer (or by the purchaser). These holes must be clean and square with the web, without burrs on either side, and will be checked with the gauges to be furnished to the manufacturer by the engineer (or by the purchaser). Should any of the holes vary from the correct size or position more than one thirty-second of an inch, the rails in question will be liable to rejection.

17. Notice of Rolling to be Given.—The manufacturer shall give to the engineer (or to the purchaser) or his representative at least seven clear days' previous notice, in writing, before the rolling of the first lot of rails, and at least three clear days' previous notice, in writing, before the rolling of any subsequent lot of rails is commenced, in order that arrangements may be made for the presence of the representative of the engineer (or of the purchaser) at the rolling.

18. Inspection and Testing.—The engineer (or the purchaser) or his representative shall have free access to the works of the manufacturer at all reasonable times; he shall be at liberty to examine the rails during any stage of their manufacture, and to reject any material or finished rail which does not conform to the terms of this specification.

Before the rails are put before the representative of the engineer (or of the purchaser) for inspection the manufacturer shall have them examined, and all rails which he admits to be defective shall be sorted out and placed in a separate stack, the representative of the engineer (or of the purchaser) being empowered to refuse to inspect any lot of rails not put in uniform lengths and sorted.

19. Testing Facilities.—The manufacturer shall supply the material required for testing free of charge and shall, at his own cost, furnish and prepare the necessary test pieces, and supply labor and appliances for such testing as may be carried out on his premises in accordance with this specification. Failing facilities at his own works for making the prescribed tests, the manufacturer shall bear the cost of carrying out the tests elsewhere.

20. Marking of Accepted Rails.—All rails accepted by the representative of the engineer (or of the purchaser) shall be stamped in his presence.

BRITISH STANDARD SPECIFICATION AND SECTIONS OF BULL HEAD RAILWAY RAILS (REVISED JULY, 1909)

1. Chemical Composition.—The steel for the rails shall be of the best quality made by the Bessemer, Siemens-Martin, or other process, as may be approved by the engineer (or by the purchaser).

The rails shall show on analysis that in chemical composition they conform to the following limits:

Carbon, from 0.35 to 0.50 per cent.
Manganese, from 0.70 to 1 per cent.
Silicon, not to exceed 0.10 per cent.
Phosphorus, not to exceed 0.075 per cent.
Sulphur, not to exceed 0.08 per cent.

2. Chemical Analysis.—The manufacturer shall make and furnish to the representative of the engineer (or of the purchaser) carbon determinations of each cast.

A complete chemical analysis, representing the average of the other elements contained in the steel, shall be similarly given for each rolling. Such complete analysis shall be made from drillings taken from the rail or from the tensile test piece or pieces. When the rolling exceeds 200 tons, an additional complete analysis shall be made for each 200 tons or part thereof.

Should the engineer (or the purchaser) desire to make independent chemical determinations, the necessary specimens and samples shall be furnished by the manufacturer. For this purpose not more than two rails in every 100 tons manufactured shall be selected by the representative of the engineer (or of the purchaser) and drillings taken with a drill of 2 inches diameter from the top of the head of the rail, unless otherwise specified by him; and if, upon being subjected to the specified tests, either fail to comply therewith, then all the rails in the cast of which the test pieces form a part may be rejected.

The representative of the engineer (or of the purchaser) may then take similar samples from a further two rails out of the same 100 tons, and should either fail to comply with the specified analysis the whole 100 tons may be rejected. In case

of difference between the engineer (or between the purchaser) and the manufacturer as to the accuracy of an analysis, either party shall have the right to have samples of the steel analyzed by an independent metallurgist, to be mutually agreed upon. The expenses attendant upon such independent analysis shall be borne by the party adjudged to be in the wrong.

3. Manufacture.—Each rail shall be made from an ingot not less than 12 inches square at the smaller end and 14 inches square at the larger end, which must be cogged down into blooms, and have sufficient crop then sheared from each end to insure soundness.

All straightening shall be done by pressure and not by hammering.

4. Permissible Variation in Weight.—A rolling margin of one-half per cent under to one-half per cent above the calculated weight will be permitted, but the calculated weight only will be paid for.

6. Templates.—Before the general manufacture of the rails is commenced the manufacturer shall, if required by the engineer (or by the purchaser), supply two sets of templates, internal and external, of approved material, for each B. S. section of rail.

Each template shall be suitably engraved with the purchaser's name, the number of the B. S. section (being the nominal weight of the rail in pounds per yard), the manufacturer's name and address, and the date of the contract.

These templates shall be submitted to the engineer (or to the purchaser) for his approval, and at the commencement of rolling the engineer will have a competent person present to approve of the section.

7. Rails to Conform to Template.—Each section of rail shall be accurately rolled to its respective template.

8. Rails to be Free from Defects.—The whole of the rails shall be of uniform section throughout, true to templates, perfectly sound and straight, and free from splits, cracks, burrs, and defects of every kind.

9. Length of Rails for Straight Line.—A quantity of short lengths will be taken in such lengths and quantities as may be ordered by the engineer (or by the purchaser), provided that these short lengths are cut down from longer lengths found to be defective at the ends only, and that the total quantity taken does not exceed 7½ per cent of the contract.

(N. B.—The committee recommend the adoption of the following as the normal lengths of rails, viz: 30 feet, 36 feet, 45 feet, or 60 feet.)

10. Permissible Variation in Length.—The rails shall be the specified length at a temperature of 60° F. No rail will be accepted which is more than three-sixteenths of an inch above or below the length specified, whether for straight or curved line.

11. Rails of Special Length for Matching in Curved Line.—When required by the engineer (or by the purchaser), rails are to be supplied from 1 to 6 inches shorter or longer than the normal specified lengths, and these special lengths are to have about 1 foot at each end painted with such colors as may be ordered.

12. Rails for Switches and Crossings.—Rails shall be supplied for switches and crossings when so ordered and such rails shall be of the required lengths and shall be cut from sound rails.

13. Branding.—The brand shall be rolled on the web of each rail to show that the rail is of British standard section and made under the conditions of this specification; the number of the B. S. section (being the nominal weight of the rail in pounds per yard), the process [8] by which the rails have been manufactured, the manufacturer's name, initials, or other recognized mark, and the month and year of manufacture shall be rolled, in letters three-quarters of an inch in size, on one side of the web of each rail—e. g., B. S. 95-B. A.,[8] ..... 4.01—and the number of the cast from which it has been rolled shall be stamped on the end of each rail in half-inch block figures.

[8] The following abbreviations are recommended: S. A., Siemens-Martin acid; S. B., Siemens-Martin basic; B. A., Bessemer acid; B. B., Bessemer basic.

14. Impact Test.—From each cast one rail shall be selected by the representative of the engineer (or of the purchaser). From this a piece 5 feet long shall be cut which shall be placed in a horizontal position with the bull head uppermost upon two iron or steel supports resting on a solid foundation, and placed so that their centers are 3 feet 6 inches apart, the upper surfaces of the supports being curved to a radius of 3 inches. The test shall comprise two blows delivered midway between the bearings from a falling iron weight of 2240 pounds, the striking face of which shall be rounded to a radius of not more than 5 inches. The height of drop for the various sections of rails shall be as tabulated below. The blows must be sustained without fracture and the rail must show a deflection between the limits given below.

B. S. section and nominal weight of rails per yard in pounds	Falling weight test					
	First blow			Second blow		
	Drop	Deflection		Drop	Deflection	
		From	To		From	To
	Feet	Inch	Inches	Feet	Inches	Inches
60	5	1	1 5/16	10	3	3 3/4
65	5	1	1 1/4	12	3	3 3/4
70	6	1	1 5/16	12	3	3 3/4
75	6	1	1 5/16	12	3	3 3/4
80	6	7/8	1 5/16	15	3	4
85	6	7/8	1 3/16	15	3	4
90	7	7/8	1 1/4	20	3	4 1/4
95	7	7/8	1 3/16	20	3	4 1/4
100	7	7/8	1 3/16	20	3	4 1/4

Should the length cut from the selected rail fail to comply with the test specified for its weight, two other rails from the same cast will be selected and similar lengths cut and tested, and the acceptance or rejection of the cast will be decided by the result of the three tests, so that if two of the rails selected fail to comply with the test the entire cast will be rejected.

15. Tensile Test.—From each 100 tons of rails the manufacturer shall (if required by the representative of the engineer or of the purchaser) cut a test piece from any rail selected as a sample rail, such test piece to be stamped to correspond with the sample rail. It shall then be placed in a testing machine of approved pattern, and shall have an ultimate tensile strength of not less than 40 tons per square inch, nor more than 48 tons per square inch, with an elongation of not less than 15 per cent upon the standard test pieces C or D. (See sketch p. 47.) Should the test piece fail to fulfill these conditions, the representative of the engineer (or of the purchaser) may require the manufacturer to test two other rails from the same cast in the same manner, and the acceptance or rejection of the cast shall be decided by the result of the three tests, so that if two of the three rails selected fail to comply with the test the entire cast will be rejected.

The representative of the engineer (or of the purchaser) may then take similar test pieces from a further two rails out of the same 100 tons and should either fail to comply with the test the whole 100 tons may be rejected.

Should the engineer (or the purchaser) desire to have independent tests made, the manufacturer shall provide the necessary test pieces, viz, two for every 200 tons, properly shaped and prepared.

16. Holes in Rails.—The holes for fishbolts shall be drilled through the web from the solid at each end of the rails, of the sizes and in the position shown in the British

standard specification for fishplates for bull head rails, or on a drawing to be supplied by the engineer (or by the purchaser). These holes must be clean and square with the web, without burrs on either side, and will be checked with the gauges to be furnished to the manufacturer by the engineer (or by the purchaser). Should any of the holes vary from the correct size or position more than one thirty-second of an inch the rails in question will be liable to rejection.

17. Notice of Rolling to be Given.—The manufacturer shall give to the engineer (or to the purchaser), or his representative, at least seven clear days' previous notice, in writing, before the rolling of the first lot of rails, and at least three clear days' previous notice, in writing, before the rolling of any subsequent lot of rails is commenced, in order that arrangements may be made for the presence of the representative of the engineer (or of the purchaser) at the rolling.

18. Inspection and Testing.—The engineer (or the purchaser) or his representative shall have access to the works of the manufacturer at all reasonable times; he shall be at liberty to examine the rails during any stage of their manufacture and to reject any material or finished rail which does not conform to the terms of this specification.

Before the rails are put before the representative of the engineer (or of the purchaser) for inspection the manufacturer shall have them examined, and all rails which he admits to be defective shall be sorted out and placed in a separate stack, the representative of the engineer (or of the purchaser) being empowered to refuse to inspect any lot of rails not put in uniform lengths and sorted.

19. Testing Facilities.—The manufacturer shall supply the material required for testing free of charge and shall, at his own cost, furnish and prepare the necessary test pieces and supply labor and appliances for such testing as may be carried out on his premises in accordance with this specification. Failing facilities at his own works for making the prescribed tests, the manufacturer shall bear the cost of carrying out the tests elsewhere.

20. Marking of Accepted Rails.—All rails accepted by the representative of the engineer (or of the purchaser) shall be stamped in his presence.

BRITISH STANDARD SPECIFICATION FOR LOCOMOTIVE CRANK AXLES (WITH ANALYSIS)

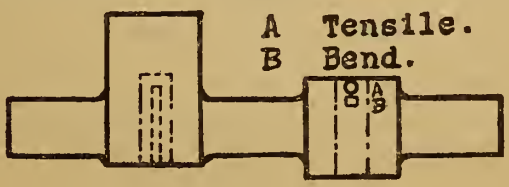
1. Quality of Material.—The crank axles shall be manufactured from the highest quality of steel made from the best selected material by the acid open-hearth process and must not show on analysis more than 0.035 per cent of sulphur or of phosphorus.

The manufacturer shall supply an analysis when required to do so.

2. Freedom from Defects.—The crank axles must be free from defects of any kind and accurately finished to the prescribed dimensions.

3. Branding.—The crank axles shall be distinctly stamped, when hot, on the web nearest the top of the ingot with such brands as the engineer (or the purchaser) may require.

4. Test Pieces.—Crank Axles Having Flat or Oval Webs.—Test pieces shall be machined cold from between each pair of webs of each crank axle and taken in the direction indicated in the sketch. The cranks shall be slotted or sawn.



Crank Axles Having Round Webs.—Test pieces shall be taken from pieces forged on each end of each crank axle and having the same diameter as the wheel seat.

In either case the test pieces shall not be detached from the axles until stamped by the representative of the engineer (or of the purchaser).

5. Mechanical Tests.—Test pieces machined from the axles as above must withstand the following tests without further reheating or any other manipulation whatever.

6. Tensile Test.—A standard test piece C or D (see sketch p. 47) must show a tensile breaking strength of not less than 30 tons per square inch, with an elongation of not less than 25 per cent, or if the crank axle be oil treated not less than 35 tons per square inch, with an elongation of not less than 20 per cent. The yield point[9] in either case must be not less than 50 per cent of the ultimate tensile strength.

7. Number of Tensile Tests.—CRANK AXLES HAVING FLAT OR OVAL WEBS.—One tensile test shall be taken from between each pair of webs of each crank axle.

CRANK AXLES HAVING ROUND WEBS.—One tensile test shall be taken from each end of each crank axle.

8. Cold-Bend Test.—A test piece 9 inches long, 1¼ inches square, with one-sixteenth inch radius at the edges, machined from the crank axles, as in clause 5, must withstand being bent cold through an angle of 90° around a bar 2½ inches diameter, and the test continued after the bar is removed by the ends being brought together without fracture.

9. Number of Cold-Bend Tests.—CRANK AXLES HAVING FLAT OR OVAL WEBS.—One cold-bend test shall be taken from between each pair of webs of each crank axle.

CRANK AXLES HAVING ROUND WEBS.—One cold-bend test shall be taken from each end of each crank axle.

10. Fatigue Test.—As an alternative to the cold-bend test, the test piece referred to in clause 8 may be placed upon bearings having a clear span of 6 inches, resting on a solid foundation, and must withstand without fracture 20 blows from a weight of 1120 pounds, having a rounded end of 1¼ inches radius, falling 6 inches. The test piece shall be reversed after the first and every alternate blow. The fall shall then be increased 12 inches and the test continued until fracture occurs.

11. Reheating or Oil Treating.—All crank axles shall be either reheated or oil treated.

12. Inspection.—The representative of the engineer (or of the purchaser) shall have free access to the works of the manufacturer at all reasonable times; he shall be at liberty to inspect the manufacture at any stage and to reject any material that does not conform to the terms of this specification.

13. Testing Facilities.—The manufacturer shall supply the material required for testing free of charge and shall, at his own cost, furnish and prepare the necessary test pieces and supply labor and appliances for such testing as may be carried out on his premises in accordance with this specification. Failing facilities at his own works for making the prescribed tests, the manufacturer shall bear the cost of carrying out the tests elsewhere.

BRITISH STANDARD SPECIFICATION FOR LOCOMOTIVE CRANK AXLES (WITHOUT ANALYSIS)

These specifications are identical with the preceding, except that in paragraph 1 no chemical analysis is specified.

[9] The yield point shall, for the purpose of this specification, be the load per square inch at which a distinctly visible increase occurs in the distance between gauge points on the test piece, observed by using dividers; or at which when the load is increased at a moderately fast rate there is a distinct drop of the testing-machine lever, or, in hydraulic machines, of the gauge finger.

BRITISH STANDARD SPECIFICATION FOR LOCOMOTIVE STRAIGHT AXLES (WITH ANALYSIS)

1. Quality of Material.—The axles shall be manufactured from the highest quality of steel made from the best selected material by the acid open-hearth process and must not show on analysis more than 0.035 per cent of sulphur or of phosphorus.

The manufacturer shall supply an analysis when required to do so.

2. Freedom from Defects.—The axles must be free from defects of any kind and accurately finished to the prescribed dimensions.

3. Branding.—The axles shall be distinctly stamped when hot, as far from the center as practicable, with such brands as the engineer (or the purchaser) may require and in such a manner that these marks shall be legible when the axles are worn out. When axles are machined the brands shall be restamped cold on one end.

4. Mechanical Tests.—Extra axles for testing in the manner described in clauses 5, 6, or 7 shall be provided by the manufacturer, at his own expense, at the rate of 2 per cent of the axles ordered under the contract, but, except as provided below, one extra axle shall be provided from each cast, and the representative of the engineer (or of the purchaser) shall select and test such of the axles as he may think proper to the extent of such percentage or extra number. The axles tested shall be held to represent correctly the quality of the casts from which they were made. In the case of a less number than 15 axles being asked for under the contract, or less than 15 being made from each cast, the manufacturer may either (1) provide an extra axle for testing, or (2) leave a piece on each axle of the same diameter as the forged end of the axle to enable the representative of the engineer (or of the purchaser) to stamp one such piece from which test pieces may be cut for the tensile test and cold-bend test specified in clauses 6 and 7. After selection of axles for testing, each test axle must comply with the following tests without further reheating or any other manipulation whatever either of the axle selected for testing or of any portion cut therefrom to furnish test pieces.

5. Falling-Weight Test.—The axle shall be placed upon bearings resting on a block of metal of not less than 5 tons weight supported on a rigid concrete or other solid foundation and must withstand, without fracture, five blows from a falling weight of 2240 pounds, as specified below.

The axle shall be turned after the first and third blow and shall be broken after testing, both in the center and at the journals.

Diameter of axle at center	Number of blows	Height of fall	Distance between points of support [10]
		Feet	Ft. in.
Under 4 inches	5	16	3 0
4 inches and under 4¼ inches	5	18	3 6
4¼ inches and under 4½ inches	5	20	3 6
4½ inches and under 4¾ inches	5	22	3 6
4¾ inches and under 5 inches	5	24	3 6
5 inches and under 5¼ inches	5	24	4 0
5¼ inches and under 5½ inches	5	28	4 0
5½ inches and under 5¾ inches	5	28	4 6
5¾ inches and under 6 inches	5	32	4 6
6 inches and over	5	35	5 0

[10] In cases where the length of the axle does not permit of these distances being adhered to the distance between the points of support shall be as great as possible.

6. Tensile Test.—A standard test piece C or D (see sketch, p. 47), machined cold from one end of each axle tested as above, must show a tensile breaking strength of 35 to 40 tons per square inch, with an elongation of not less than 25 per cent with 35 tons and 20 per cent with 40 tons, the sums of the intermediate tensile breaking strengths and corresponding elongations being not less than 60. The yield point [11] must be not less than 50 per cent of the ultimate tensile strength.

7. Cold-Bend Test.—A test piece 9 inches long and 1¼ inches square, with one-sixteenth inch radius at the edges, must withstand being bent cold through an angle of 90° around a bar 2½ inches diameter, and the test continued, after the bar is removed, by the ends being brought together without fracture.

(N. B.—This test will be taken only when a less number than 15 axles are ordered and the falling-weight test (clause 5) has not been carried out.)

8. Additional Tests Before Rejection.—In the event of the axle selected for testing not satisfying the requirements of the tensile or bend tests, and the fractured test piece indicating that the result does not fairly represent the bulk of the axles, the representative of the engineer (or of the purchaser) may, at his discretion, and at the expense of the manufacturer, take two more test pieces from the same axle for repeating the test under which failure occurred. The axles will be accepted if the results of the repeat tests are satisfactory.

Should the axle fail in the falling-weight test, the cast which the axle represents shall be rejected.

9. Independent Tests.—If the engineer (or the purchaser) desires to make independent tensile or other tests of the material, the broken pieces of any of the axles tested shall be placed at his disposal for the purpose, free of charge.

10. Reheating or Oil Treating.—All axles shall be either reheated or oil treated.

11. Inspection.—The representative of the engineer (or of the purchaser) shall have free access to the works of the manufacturer at all reasonable times; he shall be at liberty to inspect the manufacture at any stage and to reject any material that does not conform to the terms of this specification.

12. Testing Facilities.—The manufacturer shall supply the material required for testing free of charge and shall, at his own cost, furnish and prepare the necessary test pieces, and supply labor and appliances for such testing as may be carried out on his premises in accordance with this specification. Failing facilities at his own works for making the prescribed tests, the manufacturer shall bear the cost of carrying out the tests elsewhere.

BRITISH STANDARD SPECIFICATION FOR LOCOMOTIVE STRAIGHT AXLES (WITHOUT ANALYSIS)

These specifications are identical with the preceding, except that in paragraph 1 no chemical analysis is specified.

BRITISH STANDARD SPECIFICATION FOR CAR [11a] AXLES (WITH ANALYSIS)

1. Quality of Material.—The axles shall be manufactured from the highest quality of steel made from the best selected material by the acid open-hearth process and must not show on analysis more than 0.035 per cent of sulphur or of phosphorus.

The manufacturer shall supply an analysis when required to do so.

2. Freedom from Defects.—The axles must be free from defects of any kind and accurately finished to the prescribed dimensions.

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[11] The yield point shall, for the purpose of this specification, be the load per square inch at which a distinctly visible increase occurs in the distance between the gauge points on the test piece, observed by using dividers; or at which when the load is increased at a moderately fast rate there is a distinct drop of the testing machine lever, or, in hydraulic machines, of the gauge finger.

[11a] In the original specifications the terms "carriage and waggon" were used in the sense of passenger and freight car, respectively.

3. Branding.—The axles shall be distinctly stamped when hot, as far from the center as practicable, with such brands as the engineer (or the purchaser) may require and in such a manner that these marks shall be legible when the axles are worn out. When axles are machined the brands shall be restamped cold on one end.

4. Mechanical Tests.—Extra axles for testing in the manner described in clauses 5, 6, or 7 shall be provided by the manufacturer, at his own expense, at the rate of 2 per cent of the axles ordered under the contract, but, except as provided below, one extra axle shall be provided from each cast of 50, or two axles when a cast consists of more than 50, and the representative of the engineer (or of the purchaser) shall select and test such of the axles as he may think proper to the extent of such percentage or extra number. The axles tested shall be held to represent correctly the quality of the casts from which they were made. In the case of a less number than 15 axles being asked for under the contract, or less than 15 being made from each cast, the manufacturer may either (1) provide an extra axle for testing, or (2) leave a piece on each axle of the same diameter as the forged end of the axle, to enable the representative of the engineer (or of the purchaser) to stamp one such piece from which test pieces may be cut for the tensile test and cold-bend test specified in clauses 6 and 7. After selection of axles for testing, each test axle must comply with the following tests without further reheating or any other manipulation whatever, either of the axles selected for testing or of any portion cut therefrom to furnish the test pieces.

5. Falling-Weight Test.—The axle shall be placed upon bearings resting on a block of metal of not less than 5 tons weight supported on a rigid concrete or other solid foundation, and must withstand, without fracture, five blows from a falling weight of 2240 pounds, as specified below.

The axle shall be turned after the first and third blow and shall be broken in the center after testing.

Diameter of axle at center	Number of blows	Height of fall	Distance between points of support [12]
		Feet	Ft ins
Under 3¾ inches	5	15	3 0
3¾ inches and under 4 inches	5	16	3 0
4 inches and under 4¼ inches	5	18	3 6
4¼ inches and under 4½ inches	5	20	3 6
4½ inches and under 4¾ inches	5	20	3 6
4¾ inches and under 5 inches	5	24	3 6
5 inches and under 5¼ inches	5	24	4 0
5¼ inches and under 5½ inches	5	28	4 0
5½ inches and under 5¾ inches	5	28	4 6
5¾ inches and under 6 inches	5	32	4 6
6 inches and over	5	35	5 0

[12] In cases where the length of the axle does not permit of these distances being adhered to, the distance between the points of support shall be as great as possible.

6. Tensile Test.—A standard test piece, C or D (see sketch, p. 47), machined cold from one end of each axle tested as above, must show a tensile breaking strength of 35 to 40 tons per square inch, with an elongation of not less than 25 per cent with 35 tons and 20 per cent with 40 tons, the sums of the intermediate tensile breaking

strengths and corresponding elongations being not less than 60. The yield point[13] must be not less than 50 per cent of the ultimate tensile strength.

7. Cold-Bend Test.—A test piece 9 inches long and 1¼ inches square, with one-sixteenth-inch radius at the edges, must withstand being bent cold through an angle of 90° around a bar 2½ inches diameter, and the test continued after the bar is removed by the ends being brought together without fracture.

(N. B.—This test will be taken only when a less number than 15 axles are ordered and the falling-weight test (clause 5) has not been carried out.)

8. Additional Tests Before Rejection.—In the event of the axle selected for testing not satisfying the requirements of the tensile or bend tests, and the fractured test piece indicating that the result does not fairly represent the bulk of the axles, the representative of the engineer (or of the purchaser) may, at his discretion, and at the expense of the manufacturer, take two more test pieces from the same axle for repeating the test under which failure occurred. The axles will be accepted if the results of the repeat tests are satisfactory.

Should the axle fail in the falling-weight test, the cast which the axle represents shall be rejected.

9. Independent Tests.—If the engineer (or the purchaser) desires to make independent tensile or other tests of the material, the broken pieces of any of the axles tested shall be placed at his disposal for the purpose, free of charge.

10. Reheating or Oil Treating.—All axles shall be either reheated or oil treated.

11. Inspection.—The representative of the engineer (or of the purchaser) shall have free access to the works of the manufacturer at all reasonable times; he shall be at liberty to inspect the manufacture at any stage, and to reject any material that does not conform to the terms of this specification.

12. Testing Facilities.—The manufacturer shall supply the material required for testing free of charge and shall, at his own cost, furnish and prepare the necessary test pieces, and supply labor and appliances for such testing as may be carried out on his premises in accordance with this specification. Failing facilities at his own works for making the prescribed tests, the manufacturer shall bear the cost of carrying out the tests elsewhere.

BRITISH STANDARD SPECIFICATION FOR CAR AXLES (WITHOUT ANALYSIS)

These specifications are identical with the preceding, except that in paragraph 1 no chemical analysis is specified.

BRITISH STANDARD SPECIFICATION FOR LOCOMOTIVE TIRES (WITH ANALYSIS)

1. Quality of Material.—The tires shall be manufactured from the highest quality of steel made from the best selected material by the acid open-hearth process, and must not show on analysis more than 0.035 per cent of sulphur or of phosphorus.

The manufacturer shall supply an analysis when required to do so.

2. Freedom from Defects.—The tires must be free from defects of any kind and accurately finished to the prescribed dimensions.

3. Branding.—The tires shall be distinctly stamped when hot, with such brands as the engineer (or the purchaser) may require, and in such a manner that these marks shall be legible when the tires are worn out.

4. Mechanical Tests.—Extra tires for testing in the manner described in clauses 5, 6, or 7 shall be provided by the manufacturer, at his own expense, at the rate of 2

[13] The yield point shall, for the purpose of this specification, be the load per square inch at which a distinctly visible increase occurs in the distance between gauge points on the test piece, observed by using dividers; or at which, when the load is increased at a moderately fast rate, there is a distinct drop of the testing machine lever, or, in hydraulic machines, of the gauge finger.

per cent of the tires ordered under the contract, or in such extra number as will allow of one tire being selected from each cast, and the representative of the engineer (or of the purchaser) shall select and test such of the tires as he may think proper to the extent of such percentage or extra number. The tires tested by deflection shall be handed over to the engineer (or to the purchaser) free of charge, if required, and shall be held to represent the average quality of the lot from which they were selected. After selection of tires for testing each test tire must comply with the following tests without further reheating or any other manipulation whatever either of the tires selected for testing or of any portion cut therefrom to furnish the test pieces.

5. Falling-Weight Test.—The tire shall be placed in a running position with the tread resting on a block of metal of not less than 5 tons weight supported on a rigid concrete or other solid foundation, and must withstand, without fracture, blows from a falling weight of 2240 pounds. The weight shall be allowed to fall freely onto the tread from heights of 10 feet, 15 feet, 20 feet, and upwards, until the deflection of the tire corresponds to that given by the following formula, in which d is the internal diameter of the tire, as rolled, in inches, and t is the thickness of the center of the tread, as rolled, in inches:

Class C: Tensile breaking strength 50 to 55 tons per square inch

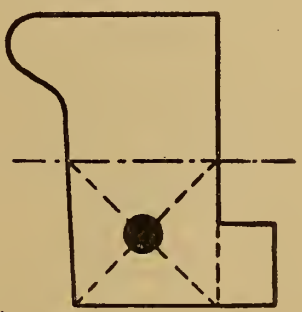
$$\frac{d^2}{50\,t^2}$$

Class D: Tensile breaking strength 56 to 62 tons per square inch

$$\frac{d^2}{55\,t^2}$$

In any case where the required deflection has been very nearly reached, the height of the final blow may be reduced at the discretion of the representative of the engineer (or of the purchaser).

6. Tensile Test.—A standard test piece, C (see sketch, p. 47), machined cold from each tire tested as above, and taken from the position shown in the sketch below must show the tensile breaking strength and minimum elongation given in the table, the intermediate elongations being in proportion.



Class	Tensile breaking strength in tons per square inch	Minimum elongation
		Per cent
C	50 to 55	13 to 11
D	56 to 62	10 to 8

7. Drop Test.—When so specified in the inquiry, each tire shall be allowed to drop freely in a running position, from the height specified below, upon a rail fastened to an iron block of not less than 2 tons in weight. Each tire shall then be turned round through an angle of 90° and dropped a second time.

Internal diameter of tire:	Up to 3½ feet	Over 3½ feet and up to 4½ feet	Over 4½ feet and up to 5½ feet	Over 5½ feet and up to 6½ feet	Over 6½ feet
Height of fall:	5 feet	4 feet	3 feet 6 inches	3 feet	2 feet 6 inches

8. Additional Tests Before Rejection.—In the event of the tire selected for testing not satisfying the requirements of clauses 5, 6, or 7, the representative of the engineer (or of the purchaser) shall, as specified below, make further tests, at the expense of the manufacturer, before finally refusing or accepting the tires represented.

(*a*) Should the tire fail in the falling-weight test, two more tires shall be taken from the same cast for testing, and the tires will be considered to have passed the test if these two tires fulfill the conditions of the falling-weight and tensile tests.

(*b*) Should the tire fail in the tensile test, and the fractured test piece indicate that the result does not fairly represent the bulk of the tires, two more tensile test pieces shall be taken from the same tire for repeating the test. The tires will be accepted if the results of the repeat tests are satisfactory.

9. Inspection.—The representative of the engineer (or of the purchaser) shall have free access to the works of the manufacturer at all reasonable times; he shall be at liberty to inspect the manufacture at any stage, and to reject any material that does not conform to the terms of this specification.

10. Testing Facilities.—The manufacturer shall supply the material required for testing free of charge and shall, at his own cost, furnish and prepare the necessary test pieces, and supply labor and appliances for such testing as may be carried out on his premises in accordance with this specification. Failing facilities at his own works for making the prescribed tests, the manufacturer shall bear the cost of carrying out the tests elsewhere.

BRITISH STANDARD SPECIFICATIONS FOR CAR (CARRIAGE AND WAGGON) TIRES (WITH ANALYSIS)

1. Quality of Material.—The tires shall be manufactured from the highest quality of steel made from the best selected material by the acid open-hearth process, and must not show on analysis more than 0.035 per cent of sulphur or of phosphorus.

The manufacturer shall supply an analysis when required to do so.

2. Freedom from Defects.—The tires must be free from defects of any kind and accurately finished to the prescribed dimensions.

3. Branding.—The tires shall be distinctly stamped when hot, with such brands as the engineer (or the purchaser) may require, and in such a manner that these marks shall be legible when the tires are worn out.

4. Mechanical Tests.—Extra tires for testing in the manner described in clauses 5, 6, or 7 shall be provided by the manufacturer, at his own expense, at the rate of 2 per cent of the tires ordered under the contract, or in such extra number as will allow of one tire being selected from each cast of 50, or two tires when a cast consists of more than 55, and the representative of the engineer (or of the purchaser) shall select and test such of the tires as he may think proper to the extent of such percentage or extra number. The tires tested by deflection shall be handed over to the engineer (or to the purchaser) free of charge, if required, and shall be held to represent the average quality of the lot from which they were selected. After selection of tires for testing each test tire must comply with the following tests, without further reheating or any other manipulation whatever, either of the tire selected for testing or of any portion cut therefrom to furnish the test pieces.

5. Falling-Weight Test.—The tire shall be placed in a running position, with the tread resting on a block of metal of not less than 5 tons weight supported on a rigid concrete or other solid foundation, and must withstand, without fracture, blows from a falling weight of 2240 pounds. The weight shall be allowed to fall freely onto the tread from heights of 10 feet, 15 feet, 20 feet, and upward, until the deflection of the tire corresponds to that given by the following formula, in which d is the internal diameter of the tire, as rolled, in inches, and t is the thickness at the center of the tread, as rolled, in inches:

Class B: Tensile breaking strength 42 to 48 tons per square inch

$$\frac{d^2}{45\ t^2}$$

Class C: Tensile breaking strength 50 to 55 tons per square inch

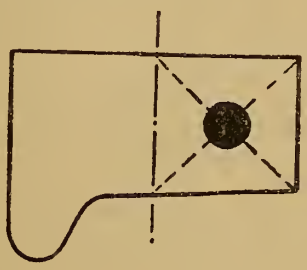
$$\frac{d^2}{50\ t^2}$$

Class D: Tensile breaking strength 56 to 62 tons per square inch

$$\frac{d^2}{55\ t^2}$$

In any case where the required deflection has been very nearly reached the height of the final blow may be reduced at the discretion of the representative of the engineer (or of the purchaser).

6. Tensile Test.—A standard test piece C (see sketch, p. 47), machined cold from each tire tested above, and taken from the portion shown in the sketch must show the tensile breaking strength and minimum elongation given in the table, the intermediate elongations being in proportion.



Class	Tensile breaking strength in tons per square inch	Minimum elongation
		Per cent
B	42 to 48	18 to 15
C	50 to 55	13 to 11
D	56 to 62	10 to 8

7. Drop Test.—When so specified in the inquiry, each tire shall be allowed to drop freely in a running position, from the height specified below, upon a rail fastened to an iron block of not less than 2 tons in weight. Each tire shall then be turned round through an angle of 90° and dropped a second time.

Internal diameter of tire	Up to 3½ feet.	Over 3½ feet.
Height of fall	5 feet.	4 feet.

8. Additional Tests Before Rejection.—In the event of the tire selected for testing not satisfying the requirements of clauses 5, 6, or 7 the representative of the engineer (or of the purchaser) shall, as specified below, make further tests, at the expense of the manufacturer, before finally refusing or accepting the tires represented.

(*a*) Should the tire fail in the falling-weight test, two more tires shall be taken from the same cast for testing, and the tires will be considered to have passed the test if these two tires fulfill the conditions of the falling-weight and tensile tests.

(*b*) Should the tire fail in the tensile test and the fractured test piece indicate that the result does not fairly represent the bulk of the tires, two more tensile test pieces shall be taken from the same tire for repeating the test. The tires will be accepted if the results of the repeat tests are satisfactory.

9. Inspection.—The representative of the engineer (or of the purchaser) shall have free access to the works of the manufacturer at all reasonable times; he shall be at liberty to inspect the manufacture at any stage and to reject any material that does not conform to the terms of this specification.

10. Testing Facilities.—The manufacturer shall supply the material required for testing free of charge and shall, at his own cost, furnish and prepare the necessary test pieces, and supply labor and appliances for such testing as may be carried out on his premises in accordance with this specification. Failing facilities at his own works for making the prescribed tests, the manufacturer shall bear the cost of carrying out the tests elsewhere.

BRITISH STANDARD SPECIFICATION FOR CAR (CARRIAGE AND WAGGON) TIRES (WITHOUT ANALYSIS)

1. Quality of Material.—The tires shall be manufactured from steel made from selected material by the acid open-hearth or acid Bessemer process.

2. Freedom from Defects.—The tires must be free from defects of any kind and accurately finished to the prescribed dimensions.

3. Branding.—The tires shall be distinctly stamped when hot with such brands as the engineer (or the purchaser) may require and in such a manner that these marks shall be legible when the tires are worn out.

4. Mechanical Tests.—Extra tires for testing in the manner described in clauses 5 and 6 shall be provided by the manufacturer, at his own expense, at the rate of 2 per cent of the tires ordered under the contract, or in such extra number as will allow of one tire being selected from each cast of 50, or two tires when a cast consists of more than 55, and the representative of the engineer (or of the purchaser) shall select and test such of the tires as he may think proper to the extent of such percentage or extra number. The tires tested by deflection shall be handed over to the engineer (or to the purchaser) free of charge, if required, and shall be held to represent the average quality of the lot from which they were selected. After selection of tires for testing, each test tire must comply with the following tests without further reheating or any other manipulation whatever either of the tire selected for testing or of any portion cut therefrom to furnish test pieces.

5. Falling-Weight Test.—The tire shall be placed in a running position, with the tread resting on a block of metal of not less than 5 tons weight supported on a rigid concrete or other solid foundation, and must withstand, without fracture, blows from a falling weight of 2240 pounds. The weight shall be allowed to fall freely onto the tread from heights of 10 feet, 15 feet, 20 feet, and upward until the deflection of the tire corresponds to that given by the following formula, in which d is the internal diameter of the tire, as rolled, in inches and t is the thickness at the center of the tread, as rolled, in inches:

Class B: Tensile breaking strength, 42 to 48 tons per square inch	Class C: Tensile breaking strength, 50 to 55 tons per square inch
$\frac{d^2}{45\ t^2}$	$\frac{d^2}{50\ t^2}$

In any case where the required deflection has been very nearly reached, the height of the final blow may be reduced at the discretion of the representative of the engineer (or of the purchaser).

6. Tensile Test.—A standard test piece C (see sketch, p. 47), machined cold from each tire tested as above, must show the tensile breaking strength and minimum elongation given in the table, the intermediate elongations being in proportion.

Class	Tensile breaking strength in tons per square inch	Minimum elongation
		Per cent
B	42 to 48	18 to 15
C	50 to 55	13 to 11

7. Additional Tests Before Rejection.—In the event of the tire selected for testing not satisfying the requirements of clauses 5 or 6, the representative of the engineer (or of the purchaser) shall, as specified below, make further tests at the expense of the manufacturer before finally refusing or accepting the tires represented.

(*a*) Should the tire fail in the falling-weight test, two more tires shall be taken from the same cast for testing, and the tires will be considered to have passed the test if these two tires fulfill the conditions of the falling-weight and tensile tests.

(*b*) Should the tire fail in the tensile test, and the fractured test piece indicate that the result does not fairly represent the bulk of the tires, two more tensile test pieces shall be taken from the same tire for repeating the test. The tires will be accepted if the results of the repeat tests are satisfactory.

8. Inspection.—The representative of the engineer (or of the purchaser) shall have free access to the works of the manufacturer at all reasonable times; he shall be at liberty to inspect the manufacture at any stage and to reject any material that does not conform to the terms of this specification.

9. Testing Facilities.—The manufacturer shall supply the material required for testing free of charge and shall, at his own cost, furnish and prepare the necessary test pieces and supply labor and appliances for such testing as may be carried out on his premises in accordance with this specification. Failing facilities at his own works for making the prescribed tests, the manufacturer shall bear the cost of carrying out the tests elsewhere.

BRITISH STANDARD SPECIFICATION FOR STEEL CASTINGS

1. Quality of Material.—The castings shall be manufactured from steel produced by an approved process, and must not show on analysis more than 0.07 per cent of sulphur or of phosphorus.

The manufacturer shall supply an analysis of each cast when required to do so.

2. Annealing.—All castings shall be thoroughly annealed in a suitable furnace before testing.

3. Molding.—The castings shall be accurately molded in accordance with the pattern or working drawing supplied by the engineer (or by the purchaser), with the addition of such lettering as may be prescribed.

4. Branding.—The cast number shall be stamped upon each casting, close to the molded number of the pattern.

5. Repairs to Defective Castings.—Any defects or unsound metal which a casting may have, from whatever cause arising, shall be left bare, and no filling with the object of obliterating such defects will be permitted unless previously sanctioned by the representative of the engineer (or of the purchaser). Any castings upon which such work has been done without such sanction having been obtained will be rejected.

6. Selection of Test Pieces.—The representative of the engineer (or of the purchaser) will examine all castings before delivery, and make a selection from the bulk of castings from which the specified tests are to be taken. He will select and stamp pieces for testing purposes, to be cut from the casting, or from lumps formed on each casting, of such size and in such a position in the mold as will furnish test pieces which shall be truly representative of the remainder of the metal.

7. Number of Tests.—The castings will be required to pass the tests specified below, according to classification. The class of castings shall be specified on the drawing.

CLASS A. GENERAL CASTINGS.—One tensile and one bend test shall be taken from each cast, and 2 per cent of the castings shall be selected by the representative of the engineer (or of the purchaser) from the bulk, to be tested to destruction.

In the case of less than 50 castings being ordered, one extra casting shall, when so specified in the inquiry, be provided by the manufacturer at his own expense for the destruction test.

CLASS B. WHEEL CENTERS.—One tensile test shall be taken from each cast and one bend test from each wheel center, but in the case of car[14] wheel centers one tensile test and one bend test shall be taken from each cast. When a destruction test is specified, the number of wheel centers selected to undergo this test shall not exceed 2 per cent.

In the case of less than 50 wheel centers being ordered, one extra wheel center shall, when so specified with the inquiry, be provided by the manufacturer at his own expense for the destruction test.

CLASS C. LARGE OR IMPORTANT CASTINGS.—One tensile test shall be taken from each cast, and one bend test from each casting.

8. Tensile Test.—A standard test piece D (see sketch, p. 47), having a gauge length of 3 inches and a sectional area of one-half square inch, or failing a 3-inch test piece, a standard test piece C (see sketch, p. 47) having a gauge length of 2 inches and a sectional area of one-fourth square inch, must, without reheating or any other manipulation whatever, show not less than the minimum tensile breaking strength and elongation given in the table.

Description of casting	Minimum tensile breaking strength per square inch	Minimum elongation
	Tons	Per cent
Castings with wearing surfaces	35	10
Other general castings and wheel centers	26	15

9. Cold-Bend Test.—In the case of castings other than those with wearing surfaces a test piece 9 inches long, turned to 1 inch diameter, must withstand being bent cold through an angle of 90° round a bar 2½ inches diameter without fracture.

10. Drop Test.—Each wheel center must withstand, without showing crack or flaw, being dropped onto a block of metal of not less than 5 tons weight supported on a rigid concrete or other solid foundation. The wheel center shall be raised and allowed to fall freely in a running position from a height of 3 feet on the end of a spoke (where such exists). In the case of wheel centers cast with balance weights the height may be reduced to 2 feet.

11. Ringing Test.—Each wheel center shall be suspended in a suitable position and struck with a quarter hammer on the rim and spokes (where such exist) and an examination made for any signs of blowholes or other defects.

[14] In all of the original British specifications the term "waggon" was used to indicate freight car.

12. **Destruction Test.**—When wheel centers are tested to destruction, the test shall be made by dropping the wheel center onto a block of metal of not less than 5 tons weight supported upon a rigid concrete or other solid foundation. The wheel center shall be raised and allowed to fall freely in a running position through distances of 5 feet and 10 feet on the end of a spoke (where such exists) and then turned through 90° and again raised and allowed to fall freely in a running position through distances of 5 feet and 10 feet on the end of a spoke (where such exists). Any sign of failure under this test will render the wheel centers represented liable to rejection. The test shall then be continued, the fall being increased 5 feet each time until fracture results or the wheel center is doubled up.

13. **Additional Tests Before Rejection.**—In the event of the casting selected for testing not satisfying the requirements of clauses 8, 9, and 12 the representative of the engineer (or of the purchaser) shall, as specified below, make further tests of castings, provided by the manufacturer at his own expense, before finally refusing or accepting the castings represented.

(*a*) TENSILE OR BEND TEST.—Should the casting fail in the tensile or bend test, and the fractured test piece indicate that the result does not fairly represent the bulk of the castings, then in castings coming under class A the tensile or bend test shall be repeated from pieces cut from the same lump.

The castings shall be accepted if this second test is satisfactory, and the whole upon close examination found free from defects.

Class B.—Tensile test pieces shall be taken from two more wheel centers from the same cast or two more bend tests shall be taken from pieces cut from the same lump.

The wheel centers shall be accepted if two of the three test results are satisfactory and the whole upon close examination found free from defects.

Class C.—Tensile test pieces shall be taken from two more castings from the same cast or two more bend tests shall be taken from pieces cut from the same lump.

The castings shall be accepted if two of the three test results are satisfactory and the whole upon close examination found free from defects.

(*b*) DESTRUCTION TEST.—Should the wheel center fail in the destruction test before enduring the first four blows and the fracture indicate that the result does not fairly represent the bulk, then two more wheel centers shall be taken for testing one from the same cast and the second from another cast. The wheel centers shall be accepted if two of the three test results are satisfactory.

14. **Inspection.**—The representative of the engineer (or of the purchaser) shall have free access to the works of the manufacturer at all reasonable times during the course of manufacture of the castings; he shall be at liberty to inspect the manufacture at any stage and to reject any casting or material that is unsound or does not otherwise conform to the terms of this specification.

15. **Testing Facilities.**—The manufacturer shall supply the castings, required under clause 7 for testing, free of charge, and shall, at his own cost, furnish and prepare the necessary test pieces and supply labor and appliances for making all tests on his premises in accordance with this specification. Failing facilities at his own works for making the prescribed tests, the manufacturer shall bear the cost of carrying out the tests elsewhere.

RAILWAY CLEARING HOUSE

STANDARD SPECIFICATION FOR THE CONSTRUCTION OF PRIVATE OWNERS' 8, 10, AND 12 TON FREIGHT CARS AND FOR THE RECONSTRUCTION OF 8 AND 10 TON FREIGHT CARS; ALSO FOR THE CONVERSION OF 8 AND 10 TON DEAD-BUFFERED FREIGHT CARS TO WORK UPON THE LINES OF THE RAILWAY COMPANIES (DECEMBER, 1907)†

13. **Tires.**—The tires to be made of acid open-hearth or acid Bessemer steel.

The tires to be 5 inches wide and not less than 2 inches nor more than 2½ inches thick on tread when finished, truly bored out, with not more than one-sixteenth

of an inch allowance for contraction. Tires to be secured to the wheels by the method of fastening shown on the standard drawings.

14. Axles.—The axles to be made of acid open-hearth or acid Bessemer steel.

15. Axles, 8 and 10 Ton Cars.—For 8 and 10 ton cars the axles to be 6 feet 6 inches in length from center to center of journals, 5¼ inches diameter through the boss of the wheel, and gradually tapered to 4½ inches in the middle. There must be no shoulder on the axle behind the boss. The journals to be 8 inches long by 3¾ inches diameter.

Axles are to be discarded when the journals are, in the case of 8-ton cars, worn below 3⅜ inches, and in the case of 10-ton cars below 3½ inches in diameter.

16. Axles, 12-Ton Cars.—For 12-ton cars the axles to be 6 feet 6 inches in length from center to center of journals, 5½ inches diameter through the boss of the wheel, and gradually tapered to 4⅞ inches in the middle. There must be no shoulder on the axle behind the boss. The journals to be 9 inches long by 4¼ inches diameter.

Axles under 12-ton cars are to be discarded when the journals are worn below 3⅞ inches in diameter.

17. Wheels (Drawings 6, 151, 152, 153, 154, and 155).—The body of the wheel to be made of wrought iron with eight solid or open spokes, or of mild steel or cast steel with eight solid spokes, to the dimensions shown on the standard drawings.

All wheel skeletons to be turned exactly to 2 feet 9 inches diameter.

The bosses must be bored out, and the wheels then forced untired onto the axle by hydraulic pressure of not less than 50 tons for 8 and 10 ton cars and 60 tons for 12-ton cars.

No keys are to be used.

21. Repairs and Reconstruction.—WHEELS.—For 8-ton cars, wheel spokes to be not less than $2\frac{15}{16}$ inches wide by $\frac{11}{16}$ inch thick; rims not less than 2⅞ inches wide by ⅝ inch thick.

For 10-ton cars, wheel spokes must not be less than $3\frac{7}{16}$ inches wide by $\frac{11}{16}$ inch thick; rims not less than 3¼ inches wide by ⅝ inch thick.

TIRES.—The tires to be not less than 5 inches wide, and when turned up to be not less than 1¼ inches thick.

Tires fastened onto the wheels with rivets or bolts to be allowed to run until the wheels require re-tiring, when they must be re-tired in the way shown on the drawings of the standard specification.

STANDARD SPECIFICATIONS AND DRAWINGS FOR PRIVATE OWNERS' FREIGHT CARS (DECEMBER, 1907) †

[Addendum to standard specifications and drawings for private owners' freight cars]

5. Wrought-Iron Axles.—Wrought-iron axles will be accepted where required provided they pass the following tests, and on the understanding that when a specification for iron axles is issued by the British standards committee the tests provided therein will be substituted:

TENSILE TEST.—A test piece of half a square inch area cut from any part of the axle tested or from the ends left on the forgings to give an ultimate strength of not more than 23 tons and not less than 20 tons per square inch, with not less than 25 per cent elongation measured over a parallel length of 3 inches.

(NOTE.—The axles must also comply with the falling-weight test as stipulated in the 1904 specification.)

6. Wheels.—Tired wheels may be forced on the axles, the pressures, however, being increased 10 tons in each case above that specified.

STANDARD SPECIFICATIONS AND TESTS FOR MATERIALS TO BE USED IN THE CONSTRUCTION OF PRIVATE OWNERS' FREIGHT CARS TO WORK UPON THE LINES OF THE RAILWAY COMPANIES (DECEMBER, 1907)†

TIRES AND AXLES

3. (*a*) The tires and axles shall be manufactured from acid open-hearth or acid Bessemer steel made from selected material.

(*b*) The tires and axles must be free from defects of any kind and accurately finished to the prescribed dimensions.

(*c*) The tires and axles to be stamped, while hot, with the day, month, and year when made, and the maker's name, and also blow or cast number to be well stamped upon each axle and on the outer face of each tire.

(*d*) The tires or axles passed by the inspector will be stamped by him, the impression of the stamp being in all cases placed close to and, where practicable, above the maker's name, so that the impression may be clearly visible to the inspector who inspects the car under which the particular tire or axle is placed.

(*e*) All stamping to be done in such a manner that the marks shall be legible when the tires and axles are worn out.

4. **Testing of Tires.**—(*a*) Extra tires for testing in the manner described in subclauses (*b*), (*c*), and (*d*) shall be provided by the manufacturer, at his own expense, at the rate of 2 per cent of the tires ordered under the contract, or in such extra number as will allow of one tire being selected from each cast, and the inspector shall select and test such of the tires as he may think proper to the extent of such percentage or extra number. The tires tested by deflection shall be held to represent the average quality of the lot from which they were selected. No tire to be less in diameter than 3 feet 1 inch on tread, and the tire selected for testing must comply with the following test without reheating or any other manipulation whatever, either of the tires selected for testing or any portion cut therefrom to furnish the test pieces.

(*b*) The tire shall be placed in a running position, with the tread resting on a block of metal of not less than 5 tons weight supported on a rigid concrete or other solid foundation, and must withstand without fracture blows from a falling weight of 2240 pounds. The weight shall be allowed to fall freely onto the tread from heights of 10 feet, 15 feet, 20 feet, and upward, the tire to deflect 1 inch for every 8 inches of its internal diameter.

In any cast where the required deflection has been very nearly reached the height of the final blow may be reduced at the discretion of the inspector.

(*c*) A standard test piece, C (p. 47), machined cold from each tire, tested as above, and taken from the position (shown in sketch, p. 47), must show the tensile breaking strength and minimum elongation given in the table, the intermediate elongations being in proportion.

Class	Tensile breaking strength in tons per square inch	Minimum elongation, per cent over parallel length of 2 inches
A	35 to 40	25 to 20
B	42 to 48	18 to 15

(*d*) In the event of the tire selected for testing not satisfying the requirements of subclauses (*b*) or (*c*) the inspector shall, as specified below, make further tests, at the expense of the manufacturer, before finally refusing or accepting the tires represented.

(*i*) Should the tire fail in the falling-weight test, two more tires shall be taken from the same cast for testing, and the tires will be considered to have passed the test if these two tires fulfill the conditions of the falling-weight and tensile-tests.

(*ii*) Should the tire fail in the tensile test and the fractured test piece indicate that the result does not fairly represent the bulk of the tires, two more tensile test pieces shall be taken from the same tire for repeating the test. The tires will be accepted if two of the three test results are satisfactory.

5. Testing of Axles.—(*a*) Extra axles for testing in the manner described in subclauses (*b*), (*c*), and (*d*) shall be provided by the manufacturer, at his own expense, at the rate of 2 per cent of the axles ordered under the contract, but, with the exception stated below, one extra axle shall be provided from each cast, and the inspector shall select and test such of the axles as he may think proper to the extent of such percentage or extra number. The axles tested shall be held to correctly represent the quality of the casts from which they were made. In the case of a less number than 15 axles being asked for under the contract, or less than 15 being made from each cast, the manufacturer may either (1) provide an extra axle for testing or (2) leave a piece on each axle of the same diameter as the forged end of the axle, to enable the inspector to stamp one such piece from which test pieces may be cut for the tensile test and cold-bend test specified in subclauses (*c*) and (*d*). Each axle selected for testing must comply with the following tests without reheating or any manipulation whatever either of the axle selected for testing or any portion cut therefrom to furnish the test pieces.

(*b*) The axle shall be placed upon bearings resting upon a block of metal of not less than 5 tons weight supported on a rigid concrete or other solid foundation and must withstand, without fracture, five blows from a falling weight of 2240 pounds, as specified below. The axle shall be turned after every blow and shall be broken in the center after testing.

	Distance apart of bearings		Height of fall
	Ft.	in.	Feet
8, 10, or 12 ton cars, 10-ton tank cars, and 10-ton tank cars for conveying class A inflammable liquids	3	6	20
15 and 30 ton cars and 12-ton tank cars	3	6	22
20-ton cars and 20-ton tank cars	4	0	30

(*c*) A standard test piece, D (see sketch, p. 47), machined cold from one end of each axle tested as above must show a tensile breaking strength of 35 to 40 tons per square inch, with an elongation of not less than 25 per cent with 35 tons and 20 per cent with 40 tons, the sums of the intermediate tensile breaking strengths and corresponding elongations being not less than 60. The elastic limit must not be less than 50 per cent of the ultimate tensile strength.

(*d*) A test piece 9 inches long and 1¼ inches square, with $\frac{1}{16}$-inch radius at the corners, must withstand being bent cold through an angle of 90° round a bar 2½ inches diameter, and the test continued after the bar is removed by the ends being brought together without fracture.

(N. B.—This test will be taken only when a less number than 15 axles is ordered and the falling-weight test (subclause (*b*)) has not been carried out.)

(*e*) In the event of the axle selected for testing not satisfying the requirements of subclauses (*b*), (*c*), or (*d*), the inspector shall, as specified below, make further tests, at the expense of the manufacturer, before finally refusing or accepting the axles represented.

(*i*) Should the axle fail in the falling-weight test, two more axles shall be taken from the same cast for testing, and the axles will be considered to have passed the test if these two axles fulfill the conditions of the falling-weight and tensile tests.

(*ii*) Should the axle fail in the tensile or bend test, and the fractured test piece indicate that the result does not fairly represent the bulk of the axles, two more test pieces shall be taken from the same axle for repeating the test under which failure occurred. The axles will be accepted if two of the three test results are satisfactory.

(*f*) If the engineer (or the purchaser) desires to make independent tensile or other tests of the material, the broken pieces of any of the axles tested shall be placed at his disposal for the purpose free of charge.

(*g*) All axles shall be either annealed or oil hardened.

STEEL CASTINGS (WHEEL CENTERS)

6. (*a*) The castings shall be manufactured from steel produced by the open-hearth or other approved process and must not show on analysis more than 0.07 per cent of sulphur or of phosphorus. The manufacturer shall supply an analysis of each cast when required to do so.

(*b*) All castings shall be thoroughly annealed in a suitable furnace before testing.

(*c*) The castings shall be accurately molded in accordance with the pattern or working drawing, with the addition of such lettering as may be prescribed.

(*d*) The cast number shall be stamped upon each casting, close to the molded number of pattern.

(*e*) Any defects or unsound metal which a casting may have, from whatever cause arising, shall be left bare, and no filling with the object of obliterating such defects will be permitted unless previously sanctioned by the inspector. Any castings upon which such work has been done without such sanction having been obtained will be rejected.

(*f*) The inspector will examine all castings before delivery and make a selection from the bulk of castings from which the specified tests are to be taken. He will select and stamp pieces for testing purposes, to be cut from the casting, or from lumps formed on each casting of such size and in such a position in the mold as will furnish test pieces which shall be truly representative of the remainder of the metal.

(*g*) The castings will be required to pass the tests specified below according to classification. The class of castings shall be specified on the drawing.

CLASS A. SMALL GENERAL CASTINGS.—One tensile and one bend test shall be taken from each melting, and 2 per cent of the castings shall be selected by the inspector from the bulk, to be tested to destruction.

CLASS B. WHEEL CENTERS.—One tensile test and one bend test shall be taken from each melting. When a destruction test is specified, the number of wheel centers selected to undergo this test shall not exceed 2 per cent.

In the case of less than 50 wheel centers being ordered, one extra wheel shall, when so specified with the inquiry, be provided by the manufacturer at his own expense for the destruction test.

(*h*) A standard test piece D (see p. 47), having a gauge length of 3 inches and a sectional area of one-half square inch, or failing a 3-inch test piece, a standard test piece, C (see p. 47), having a gauge length of 2 inches and a sectional area of one-fourth

square inch, must, without reheating or other manipulation whatever, show the minimum tensile breaking strength and elongation given in the table.

Description of casting	Minimum tensile breaking strength per square inch	Minimum elongation
	Tons	Per cent
Castings with wearing surfaces	35	10
Other general castings and wheel centers	26	15

(*i*) In the case of castings other than those with wearing surfaces, a test piece 9 inches long, turned to 1-inch diameter, must withstand being bent through an angle of 90° round a bar 2½ inches diameter without fracture.

(*j*) Each wheel center must withstand, without showing crack or flaw, being dropped onto a block of metal of not less than 5 tons weight, supported on a rigid concrete or other solid foundation. The wheel center shall be raised in a running position and allowed to fall freely from a height of 3 feet on the end of a spoke.

(*k*) Each wheel center shall be suspended in a suitable position and struck with a quarter hammer on the rim and spokes, and an examination made for any signs of blowholes or other defects.

(*l*) When wheel centers are tested to destruction, the test shall be made by dropping the wheel center onto a block of metal of not less than 5 tons weight supported upon a rigid concrete or other solid foundation. The wheel center shall be raised in a running position and allowed to drop freely 5 feet and 10 feet over the end of a spoke, and then turned through 90° and again raised in a running position and allowed to fall freely 5 feet and 10 feet on the end of a spoke. Any sign of failure under this test will render the wheel centers represented liable to rejection. The test shall then be continued, the fall being increased 5 feet each time until fracture results or the wheel center is doubled up.

(*m*) In the event of the casting selected for testing not satisfying the requirements of subclauses (*h*), (*i*), and (*l*), the inspector shall, as specified below, make further tests of castings, provided by the manufacturer at his own expense, before finally refusing or accepting the castings represented.

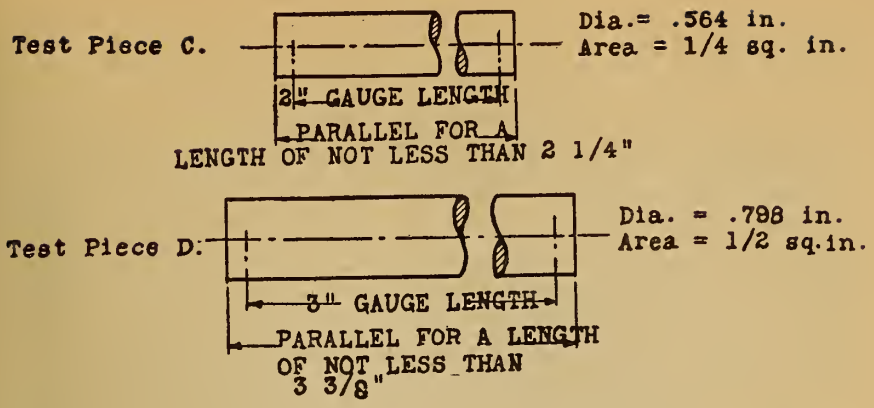
(*i*) Tensile or Bend Test.—Should the casting fail in the tensile or bend test, and the fractured test piece indicate that the result does not fairly represent the bulk of the castings, then in castings under class A, the tensile or bend test shall be repeated from pieces cut from the same lump.

The castings shall be accepted if this second test is satisfactory and the whole, upon close examination, found to be free from defects.

Class B.—Tensile and bend test pieces shall be taken from two more wheel centers from the same melt.

The wheel centers shall be accepted if two of the three test results are satisfactory and the whole, upon close examination, found free from defects.

(*ii*) Destruction Test.—Should the wheel center fail in the destruction test before enduring the first four blows, and the fracture indicate that the result does not fairly represent the bulk, then two more wheel centers shall be taken for testing, one from the same cast and the second from another cast. The wheel centers shall be accepted if two of the three test results are satisfactory.



Forms of British Standard Tensile Test Pieces.

(The sketches for forms C and D, referred to in the preceding text of British standard specifications, are here given.)

ITALY

ITALIAN STATE RAILWAYS

SPECIFICATION FOR SUPPLYING OF STEEL RAILS FOR TRACKS (1913 EDITION)

Article 1. Object of the Specifications.—The scope of the present specification is to establish the technical conditions to which the furnishing of steel rails for tracks shall be subject.

Art. 2. Profile—Section of the Rail.—The transverse section of the rails must conform to the drawings that will be transmitted to the contractor when the order is placed and must be constant throughout the length of the rail.

Only the following tolerance will be admitted: One millimeter, more or less, in the base of the rail; one-half millimeter, more or less, in all other dimensions.

The distance from the planes of the tie-plates (piani di steccatura) measured along any line parallel to the vertical axis of the rail shall not exceed by more than one-fourth millimeter the distances given in the sketches. No tolerance is allowed in the inclination of these planes with respect to the axis of the rail.

Art. 3. Length of the Rails.—(The paragraphs dealing with the actual lengths of the rails to be used are here omitted; they vary from 11.8 to 12.1 meters.)

The rails shall be measured with an iron rule previously checked by the inspector and must have the prescribed lengths at 15° C. A tolerance of 2 mm. is allowed in the length of all rails.

Art. 4. Normal Weight.—The normal weights per meter of rails are fixed as follows:

Type	Kilograms
FS 50^6	50.600
FS 46^3	46.300
RA 36 S and RA 36 D	36.100
SR 27^3	27.300

Art. 5. Production of Steel.—The rails shall be made exclusively of soft steel obtained by the converter process, acid or basic, or by the Martin process, acid or basic. Every firm submitting bids for the supply of the rails must declare in the offer the process that it intends to use in the manufacture of steel.

Art. 6. Dimensions and Treatment of the Ingots.—The central cross section of the ingot shall be equal to 20 times the cross section of the rolled rails for the rails RA 36 S, RA 36 D, and SR 27^3, and 25 times for the rails, model FS 50^6, FS 46^3.

The ingots after pouring shall be maintained in a vertical position until they are completely solidified to the center.

The manufacturing company must produce the ingots for rails to be delivered.

When, after pouring, the ingots are not taken directly to the rolls they shall be punched with their heat number as soon as their temperature permits and placed where they can be distinguished from those of other heats without possibility of mistake.

Art. 7. The Rolling.—The rolling shall be conducted in such a manner that the rails will come out straight from the rolls without flaw or discontinuity of any sort.

The finishing temperature of the rails shall be such as to assure a fine grain and homogeneous structure.

The rails shall bear the rolling mark very clearly in relief indicating the name of the manufacturing company, year of the rolling in ordinary figures, the month in Roman figures, and the type of rail.

They shall also bear letters signifying the manufacturing process used; that is, the letters B, T, MA, MB, according to whether they have been made of Bessemer, Thomas, Martin acid, or Martin basic steel. (There are omitted special clauses dealing with the size and position of the marks to be rolled into the rails.)

Art. 8. Sawing of the Rails.—The rails must be cut with the hot saw after coming from the rolls. In case only one rail is obtained from an ingot the discard shall not be less than 1½ meters of the upper part of the ingot and seven-tenths meter from the lower.

In the case where the ingot furnishes more than one rail, the discard coming from the upper part of the ingot shall be 1½ meters plus as many times 50 cm as there are other rails coming from the same ingot. In any case the discard from the end of the ingot must have such a length that the end of the rails shall have a sound and uniform structure.

When rolling more rails than one from an ingot, the company is not allowed to take a discard from the lower part of the ingot greater than that prescribed above or which is necessary in order to have a sound structure in the last rail.

Art. 9. Marking of the Rails as They Come from the Rolls.—The rails as they come from the rolls are marked with the hot punch with the number of the heat to which they belong, at a distance of about 1 meter from one end. When more than one rail is obtained from one ingot, the rail nearer the upper part of the ingot must be marked A, and the other rails, successively, with the letters B, C, etc., near the heat number.

When the rails have been milled and arranged on beds or platforms to be inspected, they are to be stamped at the end of each rail with the number of the heat, and those from the upper part of the ingot with A, etc.

Art. 10. Straightening and Cooling of the Rails.—The rails after rolling shall be left to cool slowly on level rail beds and shall not be placed the one on the other until they have been cooled sufficiently. Under no circumstances are they to be left exposed to rain or snow while they are hot.

The transportation of the hot rails and all disposition during the cooling shall be such that the rails are after cooling almost straight. The small deviations from perfect straightness, which remain after cooling, shall be removed by cold straightening in a press, with the application of blows of small force. Rails badly out of alignment shall be rejected.

Art. 11. Milling and Beveling of the Heads of the Rails.—The straightened rails shall be milled perfectly square at both ends to the prescribed length.

The heads shall be beveled at both ends in conformance with the design.

The longitudinal fin shall be removed with the file.

Art. 12. Drilling of the holes.—The number and dimensions of the holes for each rail shall conform to the design. The holes shall be drilled in the horizontal boring machine; other means of producing the holes are rigorously prohibited. The axes of the holes must be perpendicular to the plane of the web. A tolerance of 1 mm in the position and diameter of the holes with respect to the specified dimensions is allowed.

Art. 13. Tarring.—The number of rails indicated in the specifications must be covered with a mixture of one part of pitch and two parts of tar. (This paragraph is not complete; directions are given for the application of the tar preparation.)

Art. 14. Special Marks for Special Types of Rails.—(This paragraph is here omitted.)

Art. 15. Repairing—Exterior Appearance.—It is not permitted to reheat the rails in order to reduce the length or to make any repairs.

Any rails which present traces of welding or any attempt to cover up defects of rolling will be rejected without further examination.

Small surface chips (paglie) shall be removed with the chisel in the presence of the agent of the railway administration.

Rails presenting traces of fissure on the heads, chips (paglie) of any size cracks, seams, veins of scoriæ, or other defects that would alter the strength or would give rise to roughness or cavities, especially on the surface of the head and the web, shall be rejected.

Art. 16. The Testing.—Specification of the tests to be carried out:

There shall be two groups of tests, one on rails taken by heat and others on rails of groups comprising many heats and which have passed the first test favorably. Each latter group shall be composed of not more than 200 rails; the arranging of the heats in groups shall be done by the agent of the railway.

The test by heats consists in one impact test. The tests by groups consist in one bending test, one tensile test, and two etching tests.

Method of Taking Test Specimens.—The specimen for the impact test shall be of a length of about 1½ m and shall be taken hot from a rail of each heat coming from the upper part of the ingot.

The specimens for the test by group shall be taken hot from one of the rails from which have been taken the specimens for the test by heats, and all of these specimens shall be marked hot with the number of the heat. On the specimen for the impact test shall be stamped the letter U and on those for the etching test the letter A or the letter B, according to whether they refer to the end corresponding to the upper or to the lower part of the ingot.

The following diagram indicates in which way the various test specimens shall be taken from the rail:

The distance *d* shall be an exact multiple of the normal length of the rail.

In order to hasten the inspection and testing of the rails the tests by heats shall be carried on at the same time as the tests by groups, provided that in case the test by heats shall not be passed favorably in any one case that heat shall not be included in a group, and another heat will be substituted.

In the case that the company wishes to avoid using a normal length of rail for each test by heats it is permitted the inspector to accept—

1. A specimen for the impact test taken hot from a rail of each heat from the discard corresponding to the upper part of the ingot.

2. Specimens for the etching tests taken hot from the two discards of one rail above referred to, one in each part and in the immediate vicinity of the ends of the rail (in a case where one rail is obtained from one ingot), or of the first and of the last rail, in the case of the rolling of several from the same ingot.

3. One specimen for the bending test taken hot from the discard corresponding to the upper part of the ingot from another rail bar of the same heat, from which shall be taken the specimens for the etching tests.

4. One specimen for the tensile test taken cold from the specimen taken for the impact or bending test and appertaining to that heat from which were taken the specimens for the corrosion and bending tests.

It is understood that when the company (manufacturer) takes advantage of this concession the results of the tests shall not be called in question and shall have the same value as those obtained in the way first indicated.

Impact Test.—The specimen placed with the base upon two supports at a distance of 1.1 m, the supports having the form of a knife-edge with rounded edges, with a radius not greater than 125 mm, shall resist without breaking or cracking a blow of 5100 kg m for the rails model FS 50^6; 4800 kg m for the rails model FS 46^3; 4000 kg m for the rails model RA 36 S and RA 36 D; 2700 kg m for the rails model SR 27^3.

The specimen turned through 180° on the supports shall then support a second blow of an equal force upon the base without breaking.

The hammer shall be of a weight of 600 kg and shall have the striking head rounded with a radius of not more than 125 mm.

In the foundation of the supports shall be excluded materials which are elastic or yielding. The said supports shall be fixed to an anvil of pig iron and that embedded in a mass of masonry.

If the test does not give the results expected, it shall be repeated upon two other specimens of the same heat selected from two rails taken from the rail beds, and when possible from two discarded rails, and taken from that part of the rail corresponding to the higher part of the ingot.

When from one ingot more rails than one are taken, the rails to be selected for the test shall be those marked with the letter A.

If also one of these other two specimens do not pass the test, the entire heat shall be rejected. If both of such specimens satisfy the impact test, the heat shall be admitted into the group tests.

Method of Carrying Out the Group Tests—*Bending Test.*—The specimen of the length of 1½ m placed upon two supports 1 m apart must support at the center of the span for a time of five minutes a weight of 35 000 kg for the rails model FS 50^6; 32 000 kg for the rails model FS 46^3; 22 000 kg for the rails model RA 36 S and RA 36 D; 15 000 kg for the rails model SR 27^3, without giving any permanent deformation after the load has been removed. The same piece shall then be subjected to a load of 58 000 kg for the models FS 50^6, and FS 46^3; 40 000 kg for the models RA 36 S and RA 36 D; 27 000 kg for the model SR 27^3; and must not break or show any signs of fissuring.

Tensile Test.—From the center of the head of the specimen to be tested in tension shall be taken cold a bar of circular cross section having a test length of 200 mm and

a diameter of 20 mm. The axis of the small bar taken must be 20 mm below the surface of the head of the rail measured along the vertical axis of the profile of the rail.

The test specimen must have a tensile strength of not less than 65 kg per square millimeter.

The elongation in per cent of the test length of 200 mm shall be such that the product of it by the breaking load expressed in kilograms per square millimeter shall not be inferior to 900 for the rails having a tensile strength equal to or less than 72 nor inferior to 800 for those having a resistance equal to or less than 75 and greater than 72 nor inferior to 750 for those having a higher tensile strength.

All of these tests shall be carried out at a temperature between 12° and 30° C.

Etching Tests.—The specimens shall have a length of 10 to 15 cm and the transverse surface shall be ground, polished, and cleaned with chloroform or ether.

The specimens shall be attacked by a chemical reagent to be selected by the inspector or agent of the railway.

The results of the test must show that the steel has a homogeneous structure and is not segregated. Only a small amount of segregation will be allowed corresponding to the center of the specimens taken from the part of the rails coming from the upper part of the ingot.

Any decision as to results of the etching tests rests exclusively with the agent of the company. If one of the results of the tensile, bending, or etching tests shall not satisfy the prescribed requirements, the test giving deficient results shall be repeated upon two other rails of the same heat taken from the rail beds (if possible from discarded rails), the specimens to be taken from the part of the rail corresponding to the upper part of the ingot. If only one of the results of the new tests shall be unfavorable, the entire heat corresponding shall be rejected and another test on another rail of the same group shall be carried out, and if it is possible belonging to a heat near to the one discarded. If such tests give results even partially unfavorable, the whole group shall be rejected.

When from an ingot several rails are obtained, the rails to be selected for the retest shall be those having the mark "A". In this case when one of the results of the new tests shall be unfavorable before proceeding to a definite rejection of the heat it will be permitted to carry out two tests on the rails B, and if both of these shall pass the test satisfactorily, all of the rails of this heat except the A rails may be accepted.

Miscellaneous.—Besides the tests indicated above the inspector has the right to carry out any other tests (cold or hot shortness, tempering, hardness, cold-bending test on a welded specimen, etc.) that he considers of importance for the selecting of the heat upon which to carry out the group tests and in general to assure himself of the good quality of the metal with respect to the use to which it is designated, and not excluding direct tests on the ingot, which, however, shall not be in greater number than one per thousand ingots.

Art. 17. Chemical Composition.—On all of these heats which shall be indicated by the inspector there shall be carried out by the contractor a quantitative chemical analysis and such results shall be delivered to the agent of the railway, who has also the right to assist or to be present at the carrying out of the chemical analysis.

The composition of the material shall be such as not to contain more than 0.10 per cent of phosphorus or more than 0.07 per cent of sulphur.

Art. 18. Surveillance of the Manufacture and Inspection.—At the beginning of each rolling there will be taken cold two small pieces for each model, which will serve the inspector to verify whether the profile is exact, and only after such examination, and after obtaining permission of the inspector will the contractor be allowed to continue with the rolling. The two pieces accepted will be stamped by the inspector and sent by the contractor to the general office of the railway administration in Rome. The inspector must satisfy himself from time to time by taking other pieces in the manner above indicated, during the period of rolling, that the profile is being cor-

rectly reproduced. If on account of unfavorable results of the group or heat tests, especially if accompanied by unfavorable results of any of the miscellaneous tests and of the chemical analysis, or if through defects, failures, or irregularities that would come out during the various operations of testing, the inspector has reason to doubt the good quality of the rails the Administration of State Railways shall have the right to reject the whole order.

Art. 19. Weight of the Rails.—The average weight of the rails per meter is obtained by weighing 5 per cent of the rails received. The rails to be weighed shall be selected by the inspector in the various periods of rolling. If the weights as determined differ by more than 1 per cent from the normal weight referred to in paragraph 4, the State Railway Administration has the right to reject the whole lot.

FRANCE

EASTERN RAILWAYS

SPECIFICATIONS FOR STEEL RAILS OF THE TYPE VIGNOLE, 46K (1910)

1. The present specifications concern the furnishing of steel rails of the type Vignole, 46k.

2. **Profile and Weight of Rails.**—The rails must be of the form shown in the drawings and of the templets, which shall be furnished the contractor. The profile shall be rigorously adhered to over the whole length of the rail bars, and particularly at the ends, where care shall be taken not to compress or alter the section at the time of cutting.

The rails which do not reproduce exactly the form of the templet shall be rejected.

There is accorded a tolerance of +1 per cent on the weight of the rails, which are rigorously exact, nevertheless, but this is only for the purpose of allowing for the wear and play of the rolls. This tolerance shall not be applicable to rails of which the profile is not perfectly symmetrical.

The weight of 1 meter of the rail shall be determined on 100 rail bars of a section perfectly in accordance with the templet of the company.

The excess weight in total amount of each lot delivered over the normal weight increased by 1 per cent shall not be paid for.

The current manufacture of the rails shall not be authorized by the chief engineer of track until after examination of the samples submitted by the mill.

3. **Length of the Rails.**—The delivery shall comprise 80 per cent of rails, 18 m long (including those of 17.96 m and 17.90 m for laying in curves), and 20 per cent of rails 12 m long (including those of 11.96 m and 11.90 m for laying in curves), of sublengths and of coupons destined for the construction and laying of track auxiliaries.

In addition to 80 per cent of long rails, the Eastern Railway may ask for 4 per cent of rails of 24 m (including those of 23.96 m and 23.90 m for laying in curves).

The proportion of rails for use in curves will be determined as needed by the chief engineer of the railroad.

In order to facilitate the manufacture of the rails, the manufacturer may take from the 18 m rails, rejected for local defects at the ends, a portion of the 12 m rails, which he is to supply. These 12 m rails may contain the holes drilled for the splice bars.

The rails of 24 m, 23.96 m, and 23.90 m shall be tarred.

A tolerance of ± 2 mm (0.002 m) will be allowed in the length of each rail.

36^k rails for track auxiliaries will be ordered three months in advance by letters, the order including, at least 300 tons in lengths ranging from 2 to 12 m.

4. **Marking of the Rails.**—The rails shall bear at least on one side of the web letters and figures in relief indicating the year and month of manufacture and the name of the firm furnishing them. The number of the heat shall also be marked on the rail and the letter H at the end of each rail bar nearest to the top of the ingot.

5. **Quality of the Material and Manufacture of the Rails.**—The ingots for the manufacture of rails shall have a rectangular cross section with rounded angles, or an equivalent circular section, and the weight shall be sufficient to obtain, after rolling, discards of at least a length of 2.50 m for the rail bars. The discard corresponding to the top of the ingot shall be at least 1.50 m long. The surface of the ingots must be sound and uniform. The burrs and mold seams shall be chipped off with chisel. Every ingot which shows faults or breaks in continuity shall be rejected.

The agent of the company shall have the right to be present at the tests. He may make with specimens taken at the moment of casting of the ingots bending or quenching tests.

The rolling shall be as perfect as possible; the surfaces of the rails shall be sound and uniform, and the rails when finished may show neither splinters (pailles) nor fissures (criques).

The fracture must show a fine structure, fibrous (texture á arrachments), uniform and free from white or crystalline areas.

Rails which show traces of repair will be rejected.

6. Finishing and Straightening.—The rails must be as nearly straight after cooling as possible, but may be cold straightened finally in the press somewhat, care being taken to use a nonimpact and gradual pressure in the process so as to avoid fissures.

All of the rails must be cut at both ends perpendicularly to the axis; the ends must be sound and uniform without burrs (bavures) and suitably finished. The rails may not be reheated for this operation.

7. Boring of the Tie-Plate Holes.—The order will indicate whether, for the tie-plates, the rails are to be bored at the two ends, at one end, or not at all.

The boring shall be done in the boring mill, in conformity with the tracing, which shall be sent to the contractor, and which the company, moreover, shall have the right to modify in the course of execution (of order). The rails of 16 m and above shall in addition have two holes bored at or near the center of their length in accordance with the drawings furnished by the company.

The holes may be oval; they shall have the burr completely removed. Each rail in which the boring of the holes is not exactly in conformance with the tracing and templets furnished by the company shall be rejected. A tolerance of 0.5 mm (0.0005 m) shall, nevertheless, be accorded in the position of the holes.

8. Testing.—The rails shall be divided with care at the factory into groups by heats, coming from the manufacture of one or several days, and the rails not bearing the number of the heat shall be rejected. The agents shall choose in each series a certain number of rails, 1 per cent or more, which shall be subjected to the following tests.

Transverse Bending Test.—Each of the test rails placed horizontally on two supports at a distance of 1.10 m apart must be able to support for five minutes at the center of the span (*1*) without suffering any permanent deformation after the test, a load of 30 000 kg for the rail type 46k and 18 500 kg for the rail type 36k; (*2*) without bending at the center more than 25 mm, a load of 50 000 kg for the type 46k and 35 000 kg for the type 36k.

The load is then to be increased to destruction for informatory purpose, the deflections being measured during the test. Each of the two halves of the test piece so broken is then to be placed horizontally in the impact testing machine. The latter must have an anvil of 10 000 kg weight, and this must be set in masonry at least 1 m high and with an area of base of 3 square meters at least. The specimens are supported with a span of 1.10 m. These rail pieces must then withstand without breaking the blow of a hammer of 600 kg for the type 46k and 300 kg for the type 36k falling from a height of 5 m onto the center of the rail span.

With fall of.....	1 m	1.50 m	2 m	2.40 m	3 m	5 m	Type of rail	Hammer
	mm	mm	mm	mm	mm	mm	k	kg
The deformation must not be as great as.....		7	18	.....	35	60	46	600
Nor much greater than	4	6	12	18	.....	35	36	300

If one of the test pieces breaks under a fall of less than 5 m, the test will be carried out with a greater number of the rail bars, and if of these more than one-tenth do not pass the tests the whole series shall be rejected.

From each series of rails, grouped as has been described at the commencement of the present article, one may be taken, from the head of which a tensile test piece shall be cut cold. The piece turned from this rail shall be 10 cm in test length and 13.8 mm in diameter, and must have an ultimate tensile strength and elongation, which are given by the following equation

$$R+2A=92$$

where R is the tensile strength in kilograms per square millimeter and A the elongation in per cent. Moreover, the former may not be less than 65 kg per square millimeter nor the latter less than 10 per cent.

If any one of the above tests is not satisfactory, they may all be repeated on other specimens, but if one of these latter tests is not met, the lot may be rejected.

In the same way tensile test specimens are to be taken from the web, which shall be 10 cm long and 10 by 8 mm in cross section. Tests on these are to be made for the purpose of study.

Further, from a discard from one of the last rails and one from the first rails of each heat a specimen shall be taken which is at least 31 cm long and sent to the agent of the company. Tests made on these specimens are for the purpose of information only, and may not be made the basis of a rejection of the material.

9. Provisional Acceptance.—The provisional acceptance shall be made at the factory or mill by one or several agents of the company; it shall take place, as far as possible, concurrent with the manufacture, and its purpose shall be to weigh and stamp all of the rail bars satisfying the stipulated conditions.

The furnishing of the testing apparatus, as well as the labor necessary for the inspection and testing done for the purpose of obtaining assurance of the quality of the steel and of the good manufacture of the rails shall be at the charge of the contractor.

The rail bars accepted shall be stamped at their two extremities; those rejected shall in the same way be marked with a special mark at the two extremities, which shall be easily visible and indelible, in order that they may not be again presented for acceptance.

10. Guarantee.—The contractor guarantees the rails during six years, in which they are employed in frogs or in ordinary track, starting with the date of their manufacture.

Every rail which during that period shall break or crack or deteriorate in a manner other than that of ordinary wear shall be returned for replacement by the contractor.

In any case, in order to avoid heavy maintenance and transportation charges, the defective or broken rails, which may be utilized after recutting, may be kept by the company, it being understood that the contractor in that case shall only have to replace in rails of normal length the tonnage of the discards so made, and that the discards remain the property of the company, thus taking account of the expense of cutting and boring of the short rails obtained.

The new rails delivered in replacement, in application of the guarantee, must satisfy all of the conditions of the present specification; they shall be accepted provisionally at the factory and delivered at the place indicated by the order in the maximum period of one month after each return of rejected rails; they are not to be subjected to a new guarantee.

11. Right of Surveillance.—The contractor shall give free access to his shops to the engineers and agents of the company, who shall make the verifications necessary to determine whether all of the conditions of the present specification are being exactly fulfilled.

12. Responsibility of the Contractor.—The surveillance exercised by the engineer and the agents of the company at the factory of the contractor, the verifications or

tests, the provisional or partial acceptances of the rails as manufactured shall not have in any case the effect of diminishing the responsibility of the contractor; this responsibility remains full and entire until the expiration of the period of the guarantee provided in article 10.

13. Subletting of Contracts.—It is formally forbidden the contractor to cede to other contractors or to have manufactured in other factories than his own any portion of the contract which is the subject of the present specification, without the express, formal, and written permission of the company.

SPECIFICATIONS FOR STEEL AXLES FOR CARRIAGES AND FREIGHT CARS, NO. 31 M P (1905)

CLASSIFICATION.—One class.

MARKS.—Each axle bears the marks or stamps indicated in the drawings and in particular:

(1) The mark of the contractor.

(2) The number of the month and the two last digits of the number of the year of the manufacture.

(3) The number of the heat from which it comes. The use of stamps with sharp corners or edges for the marking of the axles is forbidden.

MANUFACTURE.—The axles shall be of steel ingots of basic Martin steel, but the company reserves the right to use acid steel of the same furnace if it receives guaranties of the quality of the scrap iron used in the charges. The use of charges of pig in the furnace which contain more than 0.1 per cent of phosphorus is forbidden. Each ingot shall furnish at least two axles.

The ingots are forged under a hammer of at least 10 metric tons weight or hydraulic press of appropriate power into a round which shall have a section not greater than one-fifth of its original one. In the course of that operation all seams, scale, or other surface defects, which detract from the quality or appearance of the axle, shall be removed with the chisel, hot or cold.

Each bar of this sort shall be completely free from all spongy parts from the top or bottom of the ingot and from traces of the pipe. The axles shall correspond in their finish and dimensions to the specifications and sketches, and where called for shall be ground and polished.

The axles shall be forged down before any work of machining until the diameters be within 15 mm of those of the finished axles.

The forged or rolled (ébauchés) axles shall be centered with care, and the centers shall have, after turning the axle to its final length, a depth of 15 to 20 mm, corresponding to the designs.

APPEARANCE.—The axles shall be perfectly forged, and shall present in all parts sound surfaces, free from fins, fissures, discontinuities, cavities, or other flaws.

REPAIRS.—Any trace of any repairs, with hammer or chisel, made with the purpose of masking flaws shall be a sufficient cause for rejection. The inspecting agent may authorize the repair of small superficial flaws, which he deems of no importance as regards the serviceability of the axle.

ANNEALING.—The axles must be annealed after their forging.

TOLERANCES ALLOWED IN THE DIMENSIONS—BODY.—The diameter may not be any smaller than the specifications call for, but there is allowed an excess of 3 mm.

There may, after centering, be no departure from the circular cross section in the parts which are not to be machined greater than 2 mm.

OTHER PARTS OF THE AXLE.—Forged axles (Bruts de forge) in the rough. The excess of metal, with respect to the dimensions of the finished axle, shall be (the axle being centered): In the diameters and fillets, at least 5 mm and at most 15 mm; in the total length of the axle, at most 5 mm at each end. No deficiency in length is permitted.

ROLLED AXLES (ÉBAUCHÉS).—The excess of metal is indicated in the designs and shall be such that the axle may be machined down to the finished dimensions without lack of material.

FINISHED AXLES.—The dimensions must be exactly those of the sketches.

Nature and Proportion of the Tests.—The axles are to be presented after the annealing for the tests in lots of 50 or less, all of which must be from the same heat but may be of different types.

Each axle shall have at both ends an excess of length sufficient for the obtaining of the specimen for the fracture test below.

NATURE OF THE TESTS.—The tests to which the axles shall be submitted are the following:

One axle from each lot (see above) or, at the will of the company, any fraction of a lot must be subjected to a drop test of the journal and of the body of the axle and to a tensile test.

A fracture test must be made on each finished or rolled axle presented. There may be made further a chemical analysis of each heat to determine the content of phosphorus, which may not exceed 0.07 per cent.

The inspecting agent chooses and stamps, in each lot presented, the axle destined for the drop, tensile, and chemical test.

TAKING OF THE TEST SPECIMENS.—For the purpose of the tensile test a bar is taken after the impact tests on the journal and body of the axle from the part least damaged by this test and at the surface of the axle. This bar is to bear at each end the stamp of the company.

The tensile test pieces must be cut out cold and similarly prepared for the test, and no operation of hammering, quenching, or annealing shall be used in the preparation of these test specimens.

Methods of Test and Results.—The results indicated below are the absolute minima allowed. Each test which is not passed is a sufficient cause for rejection of the corresponding lot.

DROP TEST—APPARATUS.—See No. 21 M P, page 60.

PREPARATION OF THE SPECIMEN.—Each axle chosen for the test must have the wheel seat rolled and the journals and collars turned to the required profile.

METHOD OF TEST.—The axle is placed horizontally under the impact testing machine with the wheel seat next to the journal to be tested resting on a support fixed to the base, the other wheel seat being held by a metal mass of at least 2000 kg in weight. The hammer of weight (if the weight differs a little from this, the inspecting agent shall change the height of fall in such a manner as to obtain a constant product of kilogram-meters) 500 kg is allowed to fall on the head of the journal twice in succession. The intensity of the blow struck shall be proportioned to the dimensions of the journals, and can be calculated from the following formula:

$$P\,H = 0.00054\,D^2\,L,$$

in which P represents the weight of the hammer in kilograms, H the height of fall of the hammer in meters, D the diameter of the journal in millimeters, and L the length of the journal in millimeters. The axle is then turned through 180° and subjected to two blows, the intensity of which is to be calculated from the following equation:

$$P\,H' = 0.00060\,D^2\,L.$$

Results.—The two journals must withstand the two blows of the hammer without fracturing or fissuring. The journals are then notched and broken (in the same way) and the fracture must be of a fine grain, homogeneous, and without flaws.

TESTING OF THE BODY OF THE AXLE—METHOD OF TEST.—After the breaking off of the journals the body of the axle, rough, is placed horizontally under the impact

hammer on two supports, at a distance of exactly 1.500 m in such a manner that the hammer strikes at the center. This hammer shall weigh 1000 kg (if the weight differs a little from this, the inspecting agent shall change the height of fall in such a manner as to obtain a constant product of kilogram-meters).

In order to measure, after the first bending, the elongation in per cent of the most stressed fiber, the official of tests shall mark off with a punch 200 mm, half to the right and half to the left of the axis of flexure along the lower generating line of the body of the axle.

The axle shall then be struck two blows successively with the hammer. The intensity of the blows shall be proportioned to the dimensions of the axle and shall be calculated from the following formula:

$$P\,H=0.35\,D^2,$$

in which P and H have the usual significance and D represents the diameter at the center of the body of the axle in millimeters.

Having determined the elongation of the most stressed fiber, as described above, the axle is to be turned around in the opposite direction and straightened with two blows of which the intensity can be calculated from the following formula:

$$P\,H'=0.40\,D^2.$$

The test is repeated by resubjecting the body to the same process, with the latter intensity of blow.

Results.—The body must support the four above tests without breaking or showing cracks.

The elongation in per cent over the 200 mm mentioned above must fall within the limits 9 to 13 per cent.

TENSILE TESTS.—The test piece taken as described above shall be cylindrical.

For form, marking, dimensions of the test pieces, duration, and temperature of the test, see No. 21 M P, page 61.

Results.—Axles for carriages and freight cars shall have at least a tensile strength of 45 kg per square millimeter and an elongation of 25 per cent.

FRACTURE TEST.—At each end of each axle, forged or finished, a round bar is taken in the part forming the excess length. These round bars are obtained by a cut on the lathe at the appropriate distance, and such that the cylindrical base of the notch so made concentric with the outer circle of the axle shall have a diameter at least equal to 45 mm.

The round bars shall be detached by impact in the presence of the inspecting agent.

The fracture shall show a fine grain without flaw or sponginess.

SPECIFICATIONS FOR STEEL TIRES FOR LOCOMOTIVES, TENDERS, CARRIAGES, AND FREIGHT CARS, NO. 21 M P (1906)

1. General Conditions.—CLASSIFICATION.—The tires for locomotives, tenders, passenger and freight cars are divided into four classes, A, B, C, and D.

MARKING.—Each tire bears the following marks on the outside face: The number of the heat, the trade-mark of the factory delivering the tires, the date, and characterization of the material, and other marks in accordance with the requirements or designs. These marks are stamped hot, deep enough, and as near as possible to the interior circumference, in order that they may not be removed by the machining.

MANUFACTURE.—The tires shall be made of basic Martin steel, although, when it finds sufficient guarantee of the quality of the scrap used in the charges, the company reserves the right to use the acid steel. The use of charges containing more than 0.1 per cent of phosphorus is forbidden.

The ingots are to be completely freed by one means or another of all spongy parts from the top or bottom, and of any trace of the pipe (poche de retassement).

The ingots are forged with the steam hammer into rings, which after cleaning are rolled into the profile desired.

APPEARANCE.—The tires must be sound in all respects, may not show seams, cracks, blowholes, fins, scale, or repairs (crique, gerçure, soufflure, paille, bavure, reprise), nor any flaw which would interfere with their use.

REPAIRS.—Any trace of repair work with the hammer or the chisel having for purpose the covering up of defects of any sort is cause for rejection.

The purchasing agent may have small surface defects, which he adjudges to be without effect on the service qualities of the tires, repaired.

ANNEALING.—The tires must all be annealed.

TOLERANCES IN THE DIMENSIONS.—The following tolerances only are allowed:

(1) *Diameters:*

Specified interior diameter	Interior diameter, rough	Exterior diameter
0.92 m	+0 −3 mm	−0 +4 mm
1.20 m	+0 −4 mm	−0 +5 mm
1.20 m	+0 −5 mm	−0 +6 mm

(2) *Widths:* −0 +2 mm.

Ovalization, eccentricity, and coning are limited to 2 mm per meter, whatever the diameter of the tire.

2. Nature and Number of the Tests.—The tires shall be presented for test after annealing and for this purpose shall be grouped into lots, of which all are from the same heat, but may be of different types.

NATURE OF THE TESTS.—One tire of each heat for the types A, B, and C shall undergo a drop test and a tensile test. One tire of each lot of the type D shall undergo a flattening test under the hydraulic press, followed by an impact test.

There may be made, further, a chemical analysis of each heat, and the content of phosphorus shall not be more than 0.07 per cent.

The inspecting agent shall choose and stamp, in each lot presented, the tire destined for the test.

3. Preparation of the Test Samples.—The tensile test specimen is to be taken from the samples tested in the impact machine, and shall be taken from the part least damaged by the previous test and as near as possible to the reamed surface (surface d'alésage). The place where the piece is to be taken is marked, traced, and stamped at the direction and under the care of the inspecting agent.

The cutting of the test specimens should be done entirely cold, on the lathe, with the saw, etc.

The work of the preparation of the test specimens as taken, shall also be done cold, on the lathe, without any operation of hammering, quenching, or annealing.

The test bars shall have at each end the stamp of the railway company.

4. Method of Test and Results to be Obtained.—The values given in the following are the absolute minima allowed, and a lot which does not give at least these values may be rejected.

DROP TEST—APPARATUS.—The drop test is carried out with a fall hammer, which falls in vertical guides, which shall be absolutely rigid, plane, and vertical, and arranged in such a manner that the tup falls with a minimum of friction. The center of inertia of the mass of the hammer shall be as low as possible and at the exact center of the vertical guides and the tup shall have a mass and form symmetrical to the plane of the guides. The hammer guides shall be much longer than the width of the hammer. The release of the hammer shall operate without interfering with its free fall. The hammer face shall be the surface of a cylinder whose axis is horizontal and lies in the plane of the hammer guides. The radius of this surface shall be not greater than 10 cm and the development of the cylindrical part of an angle of 90°.

The base or anvil consists of an incompressible mass which is at least 15 times as great as that of the tup, and in case it is embedded in a mass of masonry the metal part shall have a weight of not less than 10 000 kg.

METHOD OF TEST.—The tire for test is chosen by the inspecting agent and tested in the condition in which it is to be delivered. The tire placed in position on the anvil receives on the topmost part the successive blows of a hammer of weight of 1000 kg (if the weight differs a little from this value, the inspecting agent shall change the height of fall in such a manner as to obtain a constant product of kilogram-meters) falling from a height of 10 m. This height is determined by the thickness of the tire at the tread circle, and the above value holds for a thickness of 65 mm at this point. For each millimeter of difference the height is increased or diminished by 0.07 m.

Results.—The tires must support without breaking or even cracking—for type A, 2 blows; for type B, 3 blows; for type C, 6 blows.

The test may be carried to destruction with or without notching.

The fracture must show a fine grain, uniform, dense, and without flaws of any kind.

TENSILE TEST.—The test specimen shall be taken as noted in section 3, and shall be cylindrical with test heads.

FORM OF SPECIMENS.—The heads of the test specimens may be adapted to the grips of the testing machine, but no stresses in the axis of the test piece may be introduced by any such method of gripping, such as with eccentric head, etc.

For the measurement of the elongation, marks shall be made on the specimen, whose distance apart shall be given by the formula

$$L=\sqrt{66.67\,S}$$

where S denotes the area of the section.

These marks are crosses which begin at the fillet. The fraction of the length between these marks, which serves for the calculation of the elongation in per cent, shall be that which contains the section of fracture.

Dimensions are recommended for these specimens as follows:

Diameter	15.96	mm
Section	200	sq mm
Test length	147	mm
Distance between marks	115	mm
The fillet at the head shall be of radius	10	mm

DURATION AND TEMPERATURE OF THE TEST.—The test shall be by progressive loads and take between one and six minutes, depending upon the volume of the test piece, and shall be made at the ordinary temperature.

Results.—Minima allowed:

Type	Ultimate	Elongation
	Kg/mm²	Per cent
A	60	18
B	70	14
C	70	14

FLATTENING TEST UNDER THE HYDRAULIC PRESS, FOLLOWED BY THE DROP TEST—PREPARATION (FOR TYPE D ONLY).—The tire is reamed (alésé) until the thickness of the tire at the tread circle is reduced to 55 mm.

METHOD OF TEST.—The tire is then subjected to the action of a compression testing machine. The load is applied at the two extremities of the same diameter

by means of wedges of a height of 20 cm, which follow the outline of the tire and tends to flatten the tire. This machine shall have separate devices for the application and for the measuring of the load and deformation.

It must be possible to apply constantly increasing loads without shock, and the load may not be applied eccentrically (to the diameter of the tire).

The surfaces of the supports shall be of a metal which is hard and will not fail under the loads applied, and the measuring device must be as simple as possible in order that its maintenance and calibration may not be difficult and must measure the actual applied load of the machine without regard to friction of the machine, lost motion, etc.

The tire shall be flattened by 17 per cent of its original diameter. The load necessary to produce this deformation shall be at least equal to that calculated from the following formula:

$$P=15{\cdot}334{\cdot}355\,\frac{I}{D}$$

in which P is the pressure expressed in metric tons; I, the moment of inertia of the tire section with respect to an axis through its center of inertia and parallel to the axis of the tire; and D is the diameter of the tire after reaming; all of the elements entering into the dimensions are expressed in meters.

Results.—The tire tested may not break or even crack under the test mentioned.

TEST TO FOLLOW.—The tire tested in the preceding manner shall then be placed with its elongated diameter vertically in the impact machine and is there subjected to three blows of the 1000 kg hammer.

The height of fall of the first two blows shall be 10 m, and that of the last sufficient to reduce the vertical diameter of the tire to 83 per cent of its original value (before the tests).

Results.—The tire must withstand this test without fracture or fissuring. This test is to be also carried to destruction, and the fracture must be uniform, dense, and without flaws.

SPECIFICATIONS BY LETTER FROM THE CHIEF ENGINEER OF THE FRENCH EASTERN RAILWAY (1913)*

Tires.—No part of the tire shall be heated to a temperature greater than 400° C, in order to preserve the structure given to the metal by the heat treatment at the factory. (This refers to the shrinking on of the tires.)

SPECIFICATIONS, NO. 39 M P, FOR WHEEL CENTERS OF CAST STEEL (1907)

1. The present specifications relate to wheel centers of cast steel, rough, rolled, or finished as indicated in the order.

MARKING.—(Here omitted.)

MANUFACTURE.—The steel used in the manufacture of wheel centers shall be either Martin or crucible steel. The use of pig in the charges which contains more than 0.1 per cent of phosphorus is forbidden.

ANNEALING.—All of the wheel centers shall be annealed. The success of the annealing shall be determined by the examination of the fracture of the discards, which must be uniform, free from crystalline facets and ingotism, and it must be possible to obtain with a cold tool chips or drillings as in the case of ordinary steel forged or rolled, and not quenched.

APPEARANCE.—The rough castings must be perfectly cleaned, and the oxide from the annealing must have been entirely removed. The rim must be uniform, and any part distorted by the annealing or tempering shall be roughed into position (degauchies). The wheel centers shall present no traces of the juncture of the mold, shall be free from fissures and (tapures) blisters, (gouttes froids) pipes; traces of burning should

be not extensive or important enough to interfere with the proper functioning of the wheel. The company shall be the judge of whether flaws of this sort found in the material shall be a basis for rejection. The articles shall be delivered without painting with any sort of paint.

REPAIRS.—Any traces of repairs made with a view to covering up flaws shall be a sufficient cause for rejection, but the agent of the company shall reserve the right to have repaired small surface defects which, in his opinion are unimportant.

The mode of repairing to be used in such cases must be approved by the chief engineer of the railway company.

TOLERANCES ALLOWED IN THE DIMENSIONS.—The finished parts must have the dimensions given in the specifications; on the other parts the following tolerances are allowed. For any point of the plate either parallel to the axis of revolution or in a radial direction, 2 mm; for other dimensions, 10 per cent, except that the actual margin in this latter case is not allowed to exceed ±5 mm.

Tolerances in the weight of the wheel centers of the following amounts are allowed:

	Carriages, cars, tenders	Locomotive
	Per cent	Per cent
Rough wheels	− 3	−2
	+10	+8
Finished or rolled wheels	− 3	−3
	+ 7	+5

2. Nature and Distribution of the Tests—NATURE.—The tests which are to be carried out are drop and tensile tests on test pieces; bending, expanding, and equilibrium tests on the wheel centers themselves. There may also be made an analysis to determine the content of phosphorus, which may not be greater than 0.07 per cent.

NUMBER OF TESTS.—On the samples there may be made one drop and one tensile test for each heat.

On the wheels themselves there may be made one bending test on every 100 wheels for all the wheels, and one hub bore expanding test on one of every 100 of the simple wheels (roues simples) only.

The equilibrium test (for simple wheels only) is to be made on every finished wheel, and on one out of every 50 wheels which are to be furnished in the rough.

One phosphorus determination on every heat shall be made.

At the will of the company any fraction of a lot may be treated as a whole lot.

3. Taking of the Samples and Preparation of the Tests—TAKING OF THE SAMPLES.—The test bars shall, at the choice of the manufacturer, be taken from the least damaged parts of the wheel centers used in the resistance tests or from the better part of the discards of the castings after annealing.

The taking of samples from separate test ingots is only in exceptional cases allowed, and then they must be cast and annealed in as far as possible the same manner as the wheel centers themselves and in the same furnace.

The bars are to be cut out cold and shall not be subjected to any work other than that of cutting out and machining. The specimens taken from the already tested wheels, and which have been deformed less than 2 per cent, shall be cold straightened, those which have been deformed by more than 2 per cent may be straightened hot in the presence of the inspector before testing, as may also the test bars for the drop test. Otherwise no heating may be done. Even in the former case the temperature may not be greater than a dull red.

The shoulders of the test specimens for the drop test shall be lightly rounded with the file without sensible fillet.

PREPARATION OF THE WHEEL CENTERS FOR TEST.—The samples for the resistance tests shall be rough machined to within 2 mm of the finished dimensions, for the rim and length of hub, and the bore of the hub shall be reamed to the finished diameter. For reasons of economy the wheels taken for these tests shall be from those which from some small defect of form are unfit for service.

The test wheel centers and bars shall bear the stamp of the railway company.

4. Methods of Test and Results to be Obtained.—The values given below are the absolute minima, and failure to equal these values is sufficient cause for rejection.

TENSILE TEST.—(Form of test pieces, marking, dimensions, duration of the test, and temperature of the test, see No. 21 M P, p. 61.)

Results.—The tensile test specimens must show the following physical properties for the types of material M 1 and M 3:

Category	Tensile strength	Elongation
	kg/mm²	Per cent
M 1	40	20
M 3	45	15

DROP TESTS ON THE TEST BARS.—These test bars are machined to a cross section of 30 by 30 mm and a length of 200 mm.

METHOD OF TEST.—Each bar supported on edges 160 mm apart, which are fixed in an anvil weighing at least 500 kg, shall withstand the blow of a 50-kg hammer falling from a constant height of 3 m upon the center of the bar.

The striking surface of the hammer shall be part of a cylinder of radius 15 mm. developed through 90°.

The bar receives a first blow, is then turned through 180° and receives two more blows, after which it receives two blows alternately in each position until rupture.

Results.—The bar must withstand without fracturing or showing signs of cracks (counting the straightening blow) three blows at least for material shown by the tensile test to belong to the category M 1, two blows at least for material M 3. The test is then carried to destruction.

TESTS ON THE WHEELS—BENDING TEST.—The wheel center after being rough machined and reamed is placed flat on a ring support at the rim, and the hub is deformed by pressure or impact until the upper face of the hub is lowered by 4 per cent of the diameter of the rim.

Results.—During this test there should be no cracks, fissures, nor other evidence of failure produced. No account shall, however, be taken of such fissures, etc., as are formed in spokes or ribs and not ending at the hub.

After the first test the hub shall be broken off from the spokes or ribs either with a hammer or press or by any other method if fracture can not be obtained in this way. The fracture must be of fine grain, dense, uniform, and without flaw.

EXPANDING TEST (ONLY FOR SIMPLE WHEELS (ROUES SIMPLES)).—The hub is expanded, after being detached as indicated above, and starting from the bulged side, when the type permits, by the successive introduction of punches of conicity 1:100, until the inside diameter on the side from which punch was introduced has increased by 5 per cent.

Results.—This test must develop no cracks or evidences of failure. The test is carried to destruction, and the fractures must be homogeneous, of fine and regular grain, and free from sponginess (soufflure).

EQUILIBRIUM TEST (ONLY FOR THE SIMPLE WHEELS).—If the contract calls for wheels delivered unfinished, 1 of every 50 shall be turned and reamed for this test.

Method.—The (balourd) weight eccentricity shall not be more than 250 gr at a radial distance of 50 cm.

SPECIFICATIONS, NO. 41 M P, FOR WHEEL CENTERS OF THE PLATE TYPE, WITHOUT SPOKES OR RIBS (1904)

1. General Conditions.—The present specifications relate to single plate wheels of iron or steel, forged or rolled, rough machined or finished.

These wheel centers may have (1) plane or (2) curved plates.

MARKING.—Each wheel center must bear in the positions indicated in the drawings the following marks: (1) The mark of the manufacturer or contractor; (2) the number of the heat if the latter are numbered; (3) the month and year of manufacture (the latter being indicated by the two last numbers); (4) all other marks demanded by the railway company. The letters and figures shall be easily legible and shall have a height of at least 12 mm. The use of stamps having sharp edges is not permitted.

MANUFACTURE.—These wheel centers shall be made by forging or rolling cast steel, free from pipe or blow holes (soufflure), and of good quality, from open hearth or converter. The metal shall be such as to be easily machined.

ANNEALING.—The wheel centers shall be annealed.

APPEARANCE.—The parts which are not to be machined shall be well cleaned, without mold seam; the rim shall be uniform. The parts deformed by shrinkage or the annealing shall be suitably roughed into shape.

The wheel centers shall be free from cavities and fissures; the fins, cracks, and other flaws shall not be of importance from the point of view of the use of the wheels.

The company is the judge of the acceptance of wheel centers showing such flaws.

REPAIRS.—Any trace of repair work done for the purpose of covering up defects shall be a cause for rejection, although the agent of the company reserves the right to have small superficial repairs made.

DIMENSION TOLERANCES.—The parts to be finished for mounting adjustment must correspond exactly to the diagrams.

The remaining parts shall have no point in the plate displaced from its normal position more than 2 mm, and the thickness shall have no greater variation from that specified at any point than −2 mm or +3 mm.

Variations in weight are allowed, for rough wheels, of −3 or +5 per cent; for finished wheels, −3 or +4 per cent.

2. Nature and Distribution of Tests.—The tests to be carried out on the wheels themselves are (1) resistance tests (bending, expanding (hub)) and (2) equilibrium.

There may also be made a phosphorus determination on steel wheels, and the phosphorus content may not exceed 0.07 per cent.

PROPORTION OF TESTS.—(1) *Resistance Tests.*—One shall be made on every 100 wheels.

(2) *Equilibrium.*—One for 50 unmachined wheels, and on every finished wheel.

(3) *Phosphorus Determination.*—One for every heat. Any fraction of a lot may serve as a lot at the discretion of the company.

3. Taking and Preparation of Samples.—See 39 M P, page 63.

4. Methods and Results of Tests.—See 39 M P, page 64, except that the bending test should give a deformation of 2 per cent for iron and 4 per cent for steel wheels; the expanding test, an expansion of 3 per cent for iron and 5 per cent for steel wheels.

SPECIFICATIONS NO. 42 M P, FOR ASSEMBLED WHEELS FOR CARRIAGES AND CARS (1913)*

Mounting of Wheels and Axles—AXLES.—Dimensions and finishing.

CENTERS.—Dimensions and finishing.

TIRES.—Dimensions and finishing.

MOUNTING.—The pressure used in forcing wheel on axle shall be from 30 000 to 45 000 kg.

EQUILIBRIUM.—Equilibrium tests shall be carried out on mounted wheels. The balancing weights shall not be greater than 1 kg at the running surface.

[By letter from engineer in chief, September, 1913]

Mounting of Wheels on Axles.—A conicity of more than 1.5 millimeters per meter is not allowed in the wheel seat of axle.

Diameter of wheel seat	Mounting pressures
Millimeters	Kilograms
100–125	22 000–33 000
126–150	25 000–40 000
151–175	30 000–45 000
176–200	40 000–55 000
201–250	45 000–60 000

NORTHERN RAILWAYS

SPECIFICATIONS FOR STEEL RAILS OF THE TYPE VIGNOLE (1898)

Types of Rails.—The present specification has for its object the furnishing of rails of steel of the types in use by the Northern Railways Company.

These types are: Model 45k, of normal profile for track; model 43k, of special profile for the construction of track apparatus; model 30k, of normal profile for track; model 30k, of special profile for frogs.

The company will designate in the order and contract the types and the quantities of rails to be furnished, as well as the period of delivery and the conditions of the regulation of the delivery.

Profile of the Rails.—The rails shall be of the American profile, Vignole. The profile shall present exactly the form of the templet, stamped, which shall be sent to the manufacturer or contractor; it shall be rigorously adhered to over the whole length of the rail bars, and particularly at the extremities, where care shall be taken to avoid compressing or altering the section at the time of cutting.

In order to take account of the wear of the rolls, and of the precision, more or less, of their tightening, there shall be accorded a tolerance of 0.5 mm, plus or minus, in the dimensions of the transverse section, but the profile shall remain always perfectly symmetrical. The rails which within the limits indicated do not reproduce the form of the templet shall be rejected.

Length of the Rails.—The rail bars shall have the length designated in the table below, or those indicated. (The table of the lengths is omitted; these vary from 6 to 12 m.)

The company reserves the right to order rails of lengths above those indicated above up to 1/20 of the whole lot to be delivered.

There shall be accorded in the length of the rails a tolerance of ± 2 mm.

Kind and Quality of Material.—The steel for the manufacture of rails shall be Bessemer or other steel acceptable to the company.

The operations shall be conducted in such a manner as to obtain a material of the best quality with a fine, dense, and uniform grain.

The steels shall be in all respects in conformity with the specimen which shall be sent to the railway company by the contractor. The current manufacture of the rails shall not commence until this specimen shall have been accepted by the engineers of the railway company.

Ingots.—The steel shall be cast in ingot molds consisting of one piece. The form and dimensions of the ingots shall be approved by the engineer in chief of the company; this does not relieve the manufacturer of responsibility for his material.

The weight of the ingots shall be large enough to allow of obtaining discards sufficiently long to insure soundness in the rails.

The ingots shall be examined with care; those which show sponginess (soufflures), impurities, or other flaws which will not disappear during the rolling shall be rejected. Simple cavities as well as burrs (bavures) shall be removed from the surface with great care and over a surface sufficiently extended that it will render impossible the superposition during rolling of the walls of these cavities or burrs.

The agent of the company shall have an ingot broken whenever he judges it necessary to study the results of the manufacture. The fracture shall be free from blowholes. However, the total number of ingots so broken shall not exceed one five-hundredth of the whole number.

The inspector shall have the right to demand that samples of the steel shall be taken at the pouring of the ingots, and he shall assure himself of the quality of the steel by quenching and bending tests.

Manufacture of the Rails—Rolling.—The rolling shall be conducted in such a manner as to obtain the exact profiles of the rails with smooth and even surfaces and to avoid warping. Rails presenting flaws, fissures, etc., and all other faults of manufacture, shall be rejected.

All repair work, hot or cold, on the rails is forbidden.

Rails not fulfilling the conditions given above shall be rejected.

Marking.—The rails shall bear on the two faces of the web easily visible marks designating together the factory or plant, the year and month of manufacture, as well as the nature of the steel. These marks shall be in exact conformity as regards the form and the dimensions of the letters and the figures, the thickness and profile of the relief, with the drawings, which shall be sent to the contractor; they shall result from an engraving made in the last finishing rolls, with the exception of the number of the heat, which shall be applied after emergence from the rolls with a stamp. A rail which does not bear the heat number shall be rejected.

Cutting and Straightening of the Rails.—The rails shall be cut with the circular saw, after coming from the rolls, at a sufficient distance from the crushed ends that the two extremities are perfectly sound and in such a manner that that part which comes out first from the last roll and is habitually curved with a small radius shall be removed (made to disappear).

Afterwards the rails shall be straightened hot as much as possible on a platform of cast iron which is well leveled. They shall then be placed upon a well-ventilated frame platform solidly built.

Operations Done in the Cold.—The final straightening of the rail bars, necessary in order to remove the imperfections of the hot straightening, shall take place cold upon the four faces. This operation shall be executed gradually by pressure and not by blow or impact, in such a manner as to avoid all fissuring of the material of the rail; protecting pieces of convenient form shall guarantee and preserve the base.

Cutting to Length.—The final cutting to length shall be done cold, at the milling machine, or by any other method giving results equally perfect. The sections obtained in this way shall be perfectly plane and perpendicular to the axis of the rail. The burrs of these sections shall be carefully removed with the file; it is absolutely prohibited to clear them with a hammer. Cutting with the saw or shears by reheating of the ends is formally prohibited.

Boring and Grooving of the Rails.—The rails for ordinary track shall, according to the models, be bored and grooved, or only bored in conformity with the tracing which shall be sent to the contractor. In the case of rails of exceptional length the indica-

tions accompanying the order shall be followed. The cutting of the holes in the web, executed in the boring mill, shall produce holes perfectly cylindrical, and which are in accordance with the indicated diameters. The burrs of the holes shall be removed with the chisel and file. There shall be allowed a tolerance of 0.5 mm with respect to the prescribed positions.

Testing of the Rails (for the Normal Types 45k and 30k)—PRELIMINARY TESTS.—Each heat shall give one ingot heavier than the others, such that one rail can be obtained with an excess length of 1.50 m, the part crushed not being taken account of. There shall be cut off with the saw this crushed part, then at a second cut a piece of a length of 1.50 m shall be removed, which shall come from the upper part of the ingot and bear the number of the heat corresponding to the rail bar from which it was taken.

This piece of rail placed horizontally on two supports, distant 1.10 m apart, and reposing upon an anvil built according to the conditions indicated below (drop test) must support, without breaking the blow of a hammer of 300 kg weight, falling freely from a height of 5 m for the rails, model 45k, and of 3.50 m for the rails, model 30k. The amount of bending caused shall be 17 mm for the rails, model 45k, and 20 mm for the rails, model 30k. There shall be allowed a tolerance in that amount of bending of 30 per cent, more or less.

If the preliminary test is not satisfactory, a rail of the heat shall be subjected to the final tests of transverse bending, the drop and tensile test described below, and if these tests are not passed, the whole heat may be rejected. If, however, the test is satisfactory, the rails of this heat may be classed with the lot which are to be submitted to the final tests.

FINAL TESTS (EPREUVES DEFINITIVES).—The rails are to be divided with care at the factory into series coming from the production of one or several days. The agent of the company shall choose in each series for test purposes rails from different heats in the proportion of 1 per cent.

From each of the rails so chosen there shall be taken two pieces of 1.50 m in length coming from the top of the ingot; one of these is for the transverse bending test, the other for the drop test.

TRANSVERSE BENDING TEST.—One of the rail pieces, base up, is loaded at the center of a span of 1 m for five minutes—first, for model 45k rails with 36 000 kg, and for model 30k rails with 22 000 kg; then for model 45k rails with 50 000 kg, and for 30k rails with 32 000 kg—and must at the first loading show no measurable permanent set after the test and at the second a total set less than 25 mm.

The test is then carried to destruction.

DROP TEST.—The second end of the rail of a length of 1.50 m, placed horizontally on two supports at a distance of 1.10 m apart, fastened upon an anvil of cast iron of 10 000 kg weight, which itself rests upon a mass of masonry having a height of 1.0 m and an area of base of 3.30 m^2, must support without breaking the blow of a hammer of 300 kg weight falling freely on the rail bar at the center of the span, from a height of 3.50 m for the rail type 45k and 2.50 m for the rail type 30k, after having been bent the following amounts under blows of successive height as follows:

Height of fall:	1.50 m	2.00 m	2.50 m	3.00 m	3.50 m
Model 45k	4 mm	9 mm	15 mm	22 mm	30 mm
Model 30k	7 mm	18 mm	30 mm	.....	.....

A tolerance of ± 20 per cent is allowed in the amount of bending as given above.

The amount of rebound shall give some idea of the elasticity of the material.

THE TENSILE TEST.—In each rail which has been subjected to the preceding tests there shall be taken cold from the rail head a machined test specimen, which shall be subjected to the direct tensile test according to the procedure indicated below. The test length of the bar shall be 200 mm, counting between the fillets at the heads; the diameter shall be 25 mm, corresponding to a cross section of about 500 $mm.^2$

The heads of the test bars shall have a form fitted to the tensile testing machine.

In no case shall these test specimens be annealed.

LIMIT OF ELASTICITY.—These bars shall be subjected to tensile stresses in order to determine the limit of elasticity of the metal; that is, the limiting load in kilograms per square millimeters of cross section under which the specimem does not suffer any permanent elongation. This limit of elasticity in the steels for the rails of the quality defined by the bending and drop tests, shall not be less than 38 kg per square millimeter. There shall be applied an initial load of 30 kg and maintained during five minutes. Additional loads are then applied at and during intervals equal approximately to five minutes; these additional loads shall be as nearly as possible equivalent to 1 kg per square millimeter of section.

There shall be determined the maximum load, at and below which the elongation is elastic; as soon as the least permanent elongation has been observed the operation shall be discontinued, and the elastic limit will be taken as that load immediately preceding that at which there was first noticed a permanent elongation.

The test shall then be continued to rupture, starting with a load of 55 kg per square millimeter of cross section, maintained for five minutes. Additional loads of 1 kg (per square millimeter) shall then be added up to the ultimate breaking load, as is described above. The load which shall have produced rupture shall be noted and the tensile strength calculated in terms of kilograms per square millimeter of original section. This ultimate strength shall not be less than 68 kg and the elongation shall be at least 8 per cent. The value of the quantity $R+2a$ (R, ultimate strength, a the elongation in per cent, measured on a bar of 0.200 m) shall never be less than 90.

After the rupture of the test bar there shall be determined as exactly as possible the reduced section at the fracture with respect to the original section in order to calculate the reduction of area.

The permanent elongation suffered by the test bar after rupture shall be measured over a total length of the bar of 0.200 m and shall be expressed by the formula: $a=\frac{100\,x}{200}$ (x represents the total elongation in mm).

If the profile of the types of rails does not permit of the tests of transverse bending and the drop test, only the tensile test shall be carried out.

For that purpose there shall be taken, from a rail bar from each heat and in the head, a test specimen, which shall be prepared and tested in the manner indicated above.

RESULTS OF THE TESTS.—These tests shall be made in the presence of all parties (contradictoirement). If the results are satisfactory, they shall be stated in a memorandum signed by the agent of the company, and the lot shall be accepted as far as the quality of the material is concerned.

If the results obtained on any one whatever of the tests were recognized as deficient, this test shall be repeated on the same proportion of rails taken in the same series (see above), and if the new test is not satisfactory in any particular, the lot shall be definitely and entirely rejected.

The company may, moreover, prescribe and have other tests of any sort carried out, which it may deem necessary for the purpose of assuring itself with respect to the quality of the rails.

In particular cases indicated by the engineer (of the railway company) there shall be taken a specimen of the material in the form of filings of the weight of about 10 grams, which shall be addressed to the central track material service, which will have it analyzed. The results of the analysis shall be noted as further information.

SURVEILLANCE OF MANUFACTURE.—The contractors shall allow free access, day and night, of the engineers of the railway company or their agents assisting to their shops and plant, to the different operations of the manufacture of the rails, and it shall be permitted the latter to make whatever verifications they may deem necessary for

the purpose of obtaining assurance that all of the conditions of the present specifications are being exactly fulfilled.

PROVISIONAL ACCEPTANCE.—(Here omitted.)

WEIGHT OF THE RAILS.—The normal weight per meter of the rail shall be determined at the time of the delivery of the first lots, on rail bars having a section perfectly in conformity with that of the templet.

The tolerance admitted above in the dimensions of the rails contains one of ± 2 per cent, fixed from the present time, in the normal weight for the partial deliveries. Below that tolerance the rails shall be rejected; above, they may be accepted, but in that case they shall be paid for according to the normal weight augmented by the tolerance, it being understood that the excess to be paid to the contractor is limited to 1 per cent of the whole delivery.

RESPONSIBILITY AND GUARANTEE.—The surveillance exercised by the engineers of the railway company and their agents at the factory and plant of the contractors the verifications and tests, the provisional acceptance of the manufactured rails shall not have in any case the effect of diminishing the responsibility of the contractors, which shall remain full and entire until the expiration of the period of the guarantee.

The contractors guarantee the rails during six years, beginning with the date of their manufacture, that they are employed in service. Nevertheless, there are excepted from that guarantee those rails which, because of their special destination or purpose, shall have been submitted to cold or hot operations by the company (railway). With this exception, each rail which during this period shall break or deteriorate, other than by regular wear, shall be replaced by the contractors under the conditions following. (The remainder is omitted, dealing with the actual shipment of replaced rails, the final acceptance, etc.)

SPECIFICATIONS FOR CRANK AXLES (ESSIEUX COUDÉS) (1908)

1. **General Conditions.**—Crank axles of forged steel are of three types, namely, ordinary Martin steel; Martin cannon steel, quenched in oil and tempered (annealed); nickel-chrome steel, quenched and annealed.

Marking.—The trade-mark of the contractor, manufacturer, the number of the heat, the date of the manufacture, and the type of the axle shall be stamped on the two extremities of the axles.

Manufacture.—The quality and mode of manufacture of the material shall be approved by the engineer in chief before execution of a contract.

The axles shall be delivered in the rough, rough machined, or finished in accordance with the indications of the order.

They must correspond as to form and dimension, finishing, and roughing of the different parts to the indications of the designs and order. They must have smooth sound surfaces, free from fins, cavities, folds, fissures, or other flaws. Any trace of repairs with hammer or chisel made with the object of covering up defects shall be a basis for rejection.

The agent of the company may, however, authorize small superficial repairs made which he adjudges of no importance as regards the serviceability of the material.

Heat Treatment.—The axles of ordinary steel (Martin) must be carefully annealed after forging; those of the cannon steel and of nickel-chrome steel shall undergo, after being rough machined, the heat treatment above mentioned.

Tolerances.—(1) FINISHED CRANK AXLES.—The dimensions shall be in exact conformity with those of the drawings.

(2) ROUGH MACHINED CRANK AXLES.—The excess of metal is indicated in the designs and in all cases it shall be sufficient that the finished dimensions of the axle may be obtained without lack of material.

(3) AXLES AS FORGED.—The excess of metal shall be such that the finished axle may be obtained without lack of material; in any case the weights of the axle as

forged must not exceed by more than 40 per cent the weight of the finished axle. The excess shall not be paid for.

Surveillance in the Factory.—The access to the factory or plant shall be accorded always to the agents of the company charged with the surveillance of the manufacture. The tests and the verification shall take place at the choice of the company in its own shops or in those of the contractor. The latter shall be obliged to furnish at his own expense the apparatus, the templets, calipers, etc., necessary for the inspection and tests.

When the operations shall take place in the shops of the contractor, the expenses shall be borne by him. In case the tests are carried out in the shops of the company the contractor is bound to ship at his own expense, and following the instructions of the inspecting agent, the test specimens taken by the latter.

The inspection in regard to the appearance and the dimensions not taking place but partially at the factory or plant of the contractor, every crank axle which shall be finally recognized as defective, or which does not have the proper dimensions in any particular, shall be refused and sent back to the manufacturer at the latter's expense.

The axles accepted provisionally at the plant of the contractor shall receive the mark of admission by the inspecting agent; those refused shall receive the special mark of rejection.

Right of Modification, Letting of Subcontracts.—The company reserves the right to modify the form or dimensions of the articles during the execution of the order, except that it must accept (subject to the usual conditions) pieces already manufactured according to the old dimensions. The contractors must furnish the new pieces of the type asked for without any indemnity except the difference in price, if any, between the old and the new pieces, estimated at the net cost (revient).

In any case the contractors may not sublet a part or all of the order without the authorization in writing of the company.

Even if this authorization is accorded, they remain entirely responsible for all of the parts of the order, just as if they had been manufactured in their own shops, and the company may send its agents into the plants of the subcontractors for the surveillance of the manufacture as into the plant of the contractor himself.

If the processes or the machines employed in the manufacture give rise to patent royalties, these shall be at the charge and expense of the contractors, who may not shift them to the company.

Tests.—The axles shall be presented after annealing or after quenching followed by tempering, according to the material in question.

The axles of ordinary Martin steel and those of Martin cannon steel shall have an excess length sufficient that at each of the ends a bar may be cut off which is 40 mm in thickness. The nickel-chrome axles shall have an excess length at one end sufficient to allow of the taking of a 250 mm sample. These shall be attached to the axle by a notched core only of a diameter of 40 mm, obtained on the lathe, or by a plate of 10 mm in thickness obtained on the shaping machine, and shall be detached in the presence of the inspecting agent. The work necessary in the cutting out of these cylinders shall not be done until after the operations of annealing or those of quenching followed by annealing (drawing of temper).

Taking and Preparation of the Samples.—There shall be taken in each bar (see above) of 40 mm thickness of the Martin steel, or cannon steel, two test specimens, one for the tensile test and the other for the drop test. In the 250-mm bars from the nickel-chrome steel axles there shall be taken two tensile test specimens, cut out longitudinally, and two specimens for the impact test in a similar manner. The places where the specimens are to be taken shall be traced, stamped, and marked under the instructions and supervision of the inspecting agent. The cutting out shall be done cold with the shaper, saw, or milling machine.

The work of preparing the samples for the test shall also be done cold without any operations of hammering, annealing, or quenching. The test specimens shall bear at their extremities the stamp marks of the company, and the shoulders at the heads of the test specimens shall be smoothed with the file without appreciable fillet.

TENSILE TEST.—The test specimens are to be cylindrical with test heads. The dimensions recommended are the following: Test length, diameter, 15 mm; length, 100 mm.

The results to be obtained are the following (minimum values):

Material	Ultimate tensile strength	Elastic limit	Elongation
	kg/mm²	kg/mm²	Per cent
Ordinary steel, transverse-cut specimen	45	.....	20
Cannon steel, transverse-cut specimen	50	.....	20
Nickel-chrome steel, axially-cut specimen	65	45	18

DROP TEST.—The bars for the drop tests shall have a section of 30 by 30 mm and a length of 250 mm.

Each bar placed horizontally on two knife-edges with a span of 160 mm, which are fixed in an anvil weighing at least 400 kg, shall support the blow of a fall hammer of weight of 25 kg falling freely upon the center of the span from a height of 2 m in the case of the ordinary or cannon steel, and of 3.50 m in the case of the nickel-chrome steel.

The striking face of the hammer shall have a radius of about 15 mm, developed through 90°.

The bars shall support without fracture or cracking 15 blows at least of the hammer, in the same position, i, e., without turning over.

Independently of these tests the company reserves the right to make other tests which it shall deem necessary for the assurance of the quality of the axles.

All lots of axles not satisfying the above tests shall be rejected.

Guarantee.—The crank axles shall be guaranteed to run 50 000 km in three years, at the most, and to run 100 000 km in total amount in less than four years; in other words, the price paid for a crank axle is never definitely acquired by the contractor until the axle has run 100 000 km.

Whenever an axle shall be retired from service because of rupture, cracks, or any other fault or cause before having made its run of the first guarantee of 50 000 km in three years, the contractor must deliver in replacement of the axle returned, another axle under the conditions of the contract and following the instructions which shall be given him. The company of the Northern Railways will refund the axle removed from service to the contractor at the price of the rough and unfinished axle, even when it was furnished finished originally, the expense of the machining resting with the railway company. The old material will be held at the disposition of the contractor, except such parts as the company wishes to retain as specimens or for test. If the return is demanded, the material will be sent collect.

When an axle is retired from service after a run greater than 50 000 km and less than 100 000 km in less than four years, the contractor shall be bound to replace the axle removed by another axle under the conditions of the contract, and following the instructions which shall be given him. The company will pay to the contractor a fraction of the price of the axle, rough, proportional to the run which it has made since being put in service, obtained by using 100 000 as divisor. In that case the expense of finishing shall rest, as in the first case, with the company, but the old axle shall be its property.

Every axle is considered as having made virtually a run of 50 000 km on the day upon which three years expires from the date of its delivery. The run made in the fourth year shall, according to the counting regulations, be added to a run of 50 000 km.

The value of the rough axle, deduction being made for the indemnity of the run, shall be subtracted from the debit of the contractor, following the instructions of the superintendent of material and traction.

The contractor shall be released from his contract four years after the delivery of the axle to the stores of the company.

The guarantee extends in the same way to the replacing axles.

SPECIFICATIONS FOR STRAIGHT AXLES OF STEEL FOR LOCOMOTIVES (1906)*

These are identical with those for the Paris, Lyon & Mediterranean Railways.

Guarantee.—These axles must cover a distance of 80 000 km in three years at most.

SPECIFICATIONS FOR STEEL AXLES FOR CARRIAGES AND FREIGHT CARS (1904)*

These are identical with those of the Eastern Railways.

Guarantee.—These axles must cover a distance of 80 000 km in three years at most.

SPECIFICATIONS FOR WHEEL CENTERS WITHOUT RIBS OR SPOKES (1911)*

These are identical with those of the Eastern Railways.

SPECIFICATIONS FOR RIBBED OR SPOKED WHEELS (1903)*

Where differing from the Paris, Lyon & Mediterranean Railways specifications it is indicated below.

One test per lot or per 100 pieces for weldability is required.

SPECIFICATIONS FOR WHEEL CENTERS OF CAST STEEL (1911)*

These are identical with those of the Eastern Railways.

SPECIFICATIONS FOR AXLES AND WHEELS FOR FREIGHT AND PASSENGER CARS*

Mounting pressure shall be at least from 30 000 to 40 000 kg.

STATE RAILWAYS

SPECIFICATIONS FOR STEEL RAILS OF THE TYPE VIGNOLE (1911)

1. The present specification concerns the delivery to the administration of State railways of steel rails of the type Vignole, EA, 1908, weighing 42.130 kg per meter.

2. All of the rails are of the same type, and differ only in their lengths and in the positions of the holes; the quantities of the rails of each length are indicated in the order.

3. **Description of the Delivery to be Made.**—(1) The profile of the rails of the type EA and the holes, etc., for each length are determined by the drawings sent to the contractor.

(2) The rails are of hard steel, of which the quality is defined in the article 4 below.

(3) There shall be accorded on the dimensions indicated by the drawings only the following tolerances: In the profile of the rails, those determined by the drawings of the templets sent to the contractor; in the length of the rails, at a temperature of 15° C, ±2 mm; in the position and dimensions of the tie-plate holes, 0.5 mm either greater or less; the verification of this shall be by means of templets of design furnished to the contractor in the diameter of the holes for the base plate, 0.5 mm plus or minus; in their position, 0.5 mm in the direction of the height and 2 mm in the direction of the length of the rails. The tolerances described shall, as a whole, be such that in any case the weight of the rails shall remain within the limits defined below.

Normal Weight of the Rail and Tolerance.—At the beginning of the manufacture of the rails the normal weight per meter shall be determined by choosing and weighing 10 rails of great length from the first lot submitted for acceptance, and of dimensions as near as possible to those indicated by the designs.

There shall be accorded a tolerance of ± 2.5 per cent in the normal weight, but the total weight of each partial delivery shall not be less than the normal weight by more than 1 per cent.

Outside of the limits thus fixed the deliveries may be refused.

Within the limit of that tolerance, for each partial delivery, the material shall be paid for according to its real weight up to the normal weight increased by 1 per cent; above that the excess weight shall not be paid to the contractor.

4. Quality of the Material.—The steel for the manufacture of these rails shall contain more than 0.3 per cent of carbon and less than 0.11 per cent of phosphorus.

To verify these analyses, the official of tests shall take from one or several of the heats, which make each of the series of 200 rails, and at the moment which he shall indicate, test samples, of a form indicated by him and of a weight not greater than 50 grams.

Two samples shall be chosen and stamped by the inspecting agent for each of the heats for which he shall have prescribed that analysis be made.

One of these samples shall be addressed to the State Railway Administration, which shall have it analyzed. The second shall be analyzed by the contractor. These two samples shall bear the number of the heat and shall be chosen in such a manner as will render them as far as possible comparable with each other.

The method used for the analysis at the plant shall be communicated to the railway administration. The series of rails may not be accepted until the results of these analyses are known, and the entire series shall be rejected if any one of the samples chosen does not have the required analysis. If one of the samples does not fulfill the chemical specification, the number of analyses is doubled by taking fresh samples from the same heats from which the first samples were taken which did not show satisfactory results. If the results of these analyses on the whole are not satisfactory in 50% of the cases at least, the whole series shall be rejected.

5. Manufacture.—The steel for the rails shall be exclusively Siemens-Martin, Thomas, or Bessemer. The company reserves the right to bar any method of manufacture which does not permit of obtaining a constant and homogeneous analysis, particularly in the matter of phosphorus. The process shall be conducted in such a way as to produce a fine, dense grain, uniform, and a material which will take a good quench.

The Ingots.—The steel shall be cast in ingot molds of one piece. The form of the latter is subject to the approval of the administration of State railways. The weight of the ingots shall be such as to obtain after rolling a discard of at least 1 m, without prejudice to the conditions in the following (see hot saws below):

One ingot of each heat shall be heavier than the others, and shall give an extra length of rail of 1.50 m to be used in the preliminary drop test described below.

Rolling.—The rolling shall be conducted in such a way as to obtain the exact profile of the rails, with smooth and even surfaces, and to prevent any warping after coming from the last mill. The rails which show faults, discontinuities, fissures, scale, or other flaws shall be rejected. All repairs, cold or hot, of any kind are forbidden.

Hot Saws.—After coming from the last rolls the rails are cut by the hot saw at the two extremities, at a sufficient distance from the crushed ends that the ends of the rail bar are perfectly sound, and in such a manner as to remove that part curved with a small radius which is habitually found at the end which emerges first from the last rolls.

STRAIGHTENING AND COOLING.—The rail bars should be quite straight over their whole length. They are straightened, after coming from the rolls, upon a cast-iron table, well leveled, and then placed for cooling upon a solidly-built platform (chassis). The hot straightening shall be done with care, such that the bending done under the cold presses shall be reduced to a minimum.

After cooling the hot straightened rails may not have a greater curvature than that of 4 mm in 1 m.

The final straightening is done cold by nonimpact pressure, and the span of the rail in the straightening press shall be at least 1 m.

FINISHING.—The finishing of the ends to dimensions must be done by milling or other equally good method; it shall not be done by the saw or shears with reheating of the ends. The ends of the sections shall be exactly perpendicular to the axis of the rails, and the burr of machining must have been removed completely with the chisel or file; under no pretext may the sections be finished (parées) with the hammer.

TIE-PLATE HOLES.—These must be drilled or milled and not punched, and are to be freed from the burr with the file.

MARKING OF THE RAILS.—(Here omitted.) Marking is required on both faces of web.

7. Preliminary Drop Test.—From that ingot of each heat made heavier than the others there is to be taken, immediately after the rolling, in the part coming from the top of the ingot, and following the crushed end, a piece of rail of a length of 1.50 m. This bar, resting on the base on two supports at a distance of 1.10 m apart, shall support, without breaking, the blow of a fall hammer of a weight of 600 kg falling from a height of 2 m onto the center of the span. The amount of bending is noted for the purpose of obtaining information, but there is no limit prescribed.

For this test the two supports are to be of cast iron of rounded angles and resting upon an anvil of cast iron of a weight of 10 000 kg, which itself is built onto a mass of masonry of 1 m of thickness (height) and having 3.3 m^2 of area of base.

If the piece of rail is broken, a rail of the same heat is subjected to the tests of transverse bending, the drop and tensile tests described in article 8, and if the rail does not entirely satisfy these tests, the corresponding heat is rejected.

If the rail piece is not broken, the rails of the same heat are simply included in the lots or groups, as is prescribed in the following article 8.

8. Final Tests.—The rails are to be grouped at the factory into series of about 200 rails, in such a manner that the rails from the same heat are all in the same group.

The official of tests shall choose one rail from each series, taken from the heats which have been analyzed. If one or several of the heats have given unsatisfactory analyses, there shall also be chosen one rail from each of such heats. From each of the rails so taken there shall be cut off a piece 3 m in length, which shall be subjected to the following tests:

TRANSVERSE BENDING.—*First Test.*—The rail placed horizontally upon two angular supports, at a distance of 1 m apart, shall support for five minutes a pressure of 30 000 kg at the center of the span, without becoming permanently bent more than 0.5 mm after the test.

Second Test.—The same rail bar, in the same position, shall support for five minutes a load of 48 000 kg without breaking or bending more than 25 mm under the load. The load is then increased until the rail breaks.

IMPACT.—Each of the broken halves from the above tests shall be tested in impact. Each piece placed horizontally upon two supports, distant 1.10 m from each other, must support, without breaking, the blow of a fall hammer of 600 kg, falling from a height of 2 m onto the center of the span of the bar. The permanent bending caused by this blow shall not be greater than 18 mm.

If either of the tests above is not passed satisfactorily, they are both to be repeated on two other rails of the same heat, and if these are not entirely satisfactory, the whole series shall be rejected.

TENSILE TEST.—From the head of the rail, from which have been taken the coupon serving for the preceding tests, there is to be cut cold a test specimen, which has in the machined part a test length of 100 mm, and a diameter of 13.8 mm.

This test specimen must support a load increasing progressively to the rupture of the bar; if R represents the ultimate resistance to rupture in kilograms per square millimeter of the original section, and A the elongation in per cent after breaking, these two quantities must satisfy the relation

$$R + 2A \overline{>} 92$$

The ultimate strength may not, moreover, be less than 68 kg per square millimeter and the elongation not less than 8 per cent.

If the tensile test is not satisfactory, the final tests of bending, the drop and tensile tests, shall be repeated upon another rail of the same heat, but upon two pieces of 3 m in length instead of one. If either of the last two tests is not entirely satisfactory, the entire series shall be refused.

9. Provisional Acceptance at the Plant.—(Omitted.)

10. Acceptance at the Place of Delivery.—(Omitted.)

11. Guarantee.—The contractor guarantees the rails during a period of six years, dating from the time when they are put in service. In any case, the period of guarantee shall not be greater than six and one-half years from the date of the last delivery of the lot made in the corresponding half year.

At the expiration of the period of the guarantee, the state of the rails to which it is applicable is investigated in the presence of all parties.

Every rail which, during that time, has become altered by any cause other than an accident or by the usual wear, is refunded or replaced by the contractor under the conditions given below.

(The further regulations dealing with the actual process of replacing the rails, or of refunding for them, are omitted.)

12. Delay in the Delivery.—(Omitted.)

13. Transport and Place of Delivery.—(Omitted.)

(These specifications have since been modified.)

MODIFICATION OF 1913.

The statement "Rails, Vignole, of steel, type EA, model 1908, weighing 42.130 kg per meter" is annulled and replaced by "Vignole steel rails, type EV, model 1911, weighing 45.520 kg per meter."

The paragraph dealing with the transverse bending test is annulled and replaced by the following:

TRANSVERSE BENDING TEST.—*First Test.*—The rail placed horizontally on two points of support of angular form, at a distance of 1 m apart, must support for five minutes at the center of the span a pressure of 32 000 kg without taking a permanent set of more than 0.5 mm after the test.

Second Test.—The same bar in the same position must support during five minutes a load of 51 000 kg without breaking or presenting an amount of bend, measured under load, of more than 25 mm. The load is then increased until rupture occurs.

The clause concerning the amount of bending required under the drop test is altered in the following way:

The permanent bending obtained with a height of fall of 2 m shall not be greater than 17 mm.

Article 13 is annulled.

PARTICULAR CONDITIONS.—The contractor shall have a specimen accepted before beginning the current manufacture of the rails.

The rails coming from the recutting of the rails of greater length shall be presented with the original holes (oval) at one extremity.

SPECIFICATIONS FOR STRAIGHT AXLES FOR PASSENGER AND FREIGHT CARS (1905)

(These are identical with those of the French Eastern Railways, No. 31 M P, p. 57.)

PARIS, LYON & MEDITERRANEAN RAILWAYS

SPECIFICATIONS FOR STEEL RAILS (1910)

The present specifications concern the furnishing of steel rails. (Several paragraphs deal with types of rail, lengths, design, dimensions, and weight which are not given in full below.)

The types of rails are the following: LP, 48 kg, main lines; PM–A, 39 kg, secondary lines; PLM2, 41.6 kg, special.

Tolerances are allowed of 0.5 mm in the section dimensions and from 1.5 to 2 mm in the length.

A margin in weight of ± 2 per cent is allowed.

Manufacture.—The rails shall be of acid or basic steel, Martin or Bessemer, unless by special permit by the chief engineer of the company.

The process shall be conducted in such a way as to give the steel the best properties, a fine and uniformly dense grain, and it must be capable of being hardened well by quenching.

The current manufacture of the rails shall not commence until after the approval by the engineers of the company of the samples, which shall be sent by the contractor, in order that the former may judge of the nature of the grain of the steel and of the exactitude of the profile.

Carbon Content.—There shall be taken in each heat a specimen, which shall be forged in the shape of a bar 30 by 20 mm and which is to be subjected to a quenching test.

The inspector, whenever the quenching tests do not appear satisfactory to him, may, at all times that he deems appropriate, follow up these investigations in the following manner:

He shall have taken from all of the test specimens obtained in the course of the day one, which shall be stamped with a distinctive mark; the same day or in the evening he shall analyze this specimen in his laboratory, by the method of Eggertz or other similar method, with the purpose of determining the content of carbon. The next day, before 10 o'clock in the morning, he shall notify the factory of the result of the analysis. In case the analysis is contested, the operation shall be recommenced at the bureau, and under the care of the inspector, in the presence of the agents of the factory.

Whenever the proportion of carbon, thus determined, shall be less than 3 grams per kilogram, the heat having furnished the test piece, but only this heat, shall be rejected, and the ingots or the rails coming from it shall be grouped in such a manner that the factory may not dispose of them except in sight and with the knowledge of the inspector.

Ingots.—The steel shall be cast in ingot molds of one piece.

The ingots shall be of rectangular section with rounded angles and of dimensions acceptable to the engineer in chief.

The weight of these ingots shall be sufficient to obtain, after blooming, crops whose length is great enough that the pipes and blowholes have been removed.

The stripping of the ingots may not be begun until after a half hour from the time of pouring.

Structure of the Ingots.—An ingot may be fractured transversely or longitudinally, at the demand of the inspector, at any time deemed necessary in order to study the results of the process of the manufacture and to be able to judge of the size of the waste or crop which is necessary to demand; the number of ingots so fractured shall not be more than 1/2000 of the total number. In order to make the fracture, a notch may be made.

Rolling.—The rolling shall be conducted in such a manner as to obtain the exact form of the rails, with smooth surfaces, and avoid warping after emergence from the mills. Rails which show faults, discontinuities, cracks, repairs (reprises), fins, or all other faults of manufacture shall be rejected.

Straightening of the Rails.—These shall be as straight as possible as they come from the mills and shall be then straightened hot after coming from the last rolls on bed of cast iron and laid on a solidly supported rail bed to cool.

The final straightening, necessary in order to remove imperfections in the hot straightening, shall be done cold and gradually by pressure, without impact, in such a manner as to avoid causing fissures in the rail; appropriate shoes will be used to protect the flange and base.

Sawing and Finishing.—The rail bars shall be cut, at the hot saw, at the ends, at a distance from the crushed extremities sufficient that these ends shall be perfectly sound, and that the part coming first from the last rolls, and which is habitually curved with small radius, shall be removed.

The lengths at the ends of the rails cut off shall be at least 80 cm at the part corresponding to the top of the ingot, and 20 cm, to the lower part of the same.

The rail ends are finished properly at the milling machine or lathe; cutting with the saw or shears by heating is forbidden. This finishing of the ends shall be conducted in such a manner as not to alter the section at the ends.

The end sections shall be exactly perpendicular to the axis of the rail, and the burr formed by the machining shall be removed with a tool, chisel, or file; the use of the hammer is absolutely forbidden.

Boring of the Tie-Plate Holes.—These shall be bored or milled out and the burr removed with the file. A tolerance of 0.5 mm in the position of these holes with respect to the ones indicated in the drawings is allowed.

Repairs.—All repairs, cold or hot, are forbidden.

Marking of the Rails.—The rails shall bear on the two web faccs easily visible marks indicating the name of the factory, the date and quarter year (trimestre) of the manufacture, and the kind of steel, whether Bessemer, Martin, or Siemens; these marks shall be followed by the letter G. These marks shall exactly conform as far as form and dimensions of the letters and figures, thickness, and profile of the relief to the special designs which shall be sent to the contractor by the company. They shall result from an engraving made in the last finishing rolls, with the exception of the special mark indicating the kind of steel, which may be applied after coming from the rolls by a stamp; in the same way the number of the heat shall be punched hot on each rail.

Preliminary Drop Test on an End of a Rail from Each Heat.—Every heat shall give one ingot heavier than the others, in order that in the rolling one rail bar can be obtained which has an excess length of 70 cm, not counting the crushed end. At the saw this crushed end shall be first cut off, and then this excess length of 0.70 m. This part should come from the top of the ingot, and the number of the heat should be marked upon it.

This test piece of 70 cm of length is then placed horizontally upon supports with a span of 50 cm and must withstand without breaking the blow of a 600 kg fall hammer falling freely from a height of 2.50 m for the rails of the type PM–A and PLM–2, and of 3 m for the rail LP and striking at the center. This test is then carried to destruction for informatory purposes.

The two supports shall be of cast iron with rounded angles, and reposing upon an anvil of 10 000 kg of weight, which in turn is fixed in masonry of 1 m depth and of 3.3 m^2 of area at the base.

If any one of the rails fails to meet this test, a rail of the corresponding heat shall be subjected to the final tests described below, namely, those of bending under pressure and impact and the tensile test.

If the rail fails to meet these tests or any one of them, the rails of the whole heat shall be rejected.

When, on the contrary, the preliminary test is met satisfactorily, the rails of the corresponding heat shall be classed with the rails to be subjected to the final tests.

Final Tests of Bending with Pressure and Impact.—The rails shall be divided with care in the mills into heats and in lots of about 300 metric tons at most coming from the rolling of one or several days. The official of tests shall choose in each lot three rails coming from different heats, and from each two samples shall be taken, one of 1.50 m, the other of 3 m in length, which are to be tested, as follows:

First Test.—Each fragment of length 1.50 m resting on the base and supported with a span of 1 m on angular supports must bear the weight on the head during five minutes of 30 000 kg for the rails PM–A and PLM–2 and of 40 000 kg for the rails LP without bending more than 0.5 mm at the center.

Second Test.—The same piece of rail in the same position must, without warping, support the pressure of 45 000 kg for the rails PM–A and PLM–2, and 60 000 kg for the rails LP, without bending more than 20 mm. The test is then carried to destruction.

Third Test.—Each piece of rail of length 3 m is placed upon supports with a span of 1.10 m, and is subjected to the blow of a fall hammer of 600-kg weight falling freely from the height of 1.50 m for the rails PM–A and PLM–2 and 1.75 m for the rails LP, and striking at the center of the span. There shall be no permanent deformation after this test greater than a bending of 12 mm at the center, and the rail must not break. A drop tensile test will not be required for bridge rails. The base and anvil of this machine are described above.

Tensile Tests—Fourth Test.—There shall be made a tensile test on test pieces taken from each of the three rails chosen from each lot. Each test bar cut out cold from the center of the head shall have a test length of 100 mm (between marks) and 13.8 mm diameter. The test bar must support, without breaking, a force of 70 kg per square millimeter, and show after rupture a total elongation of at least 12 per cent of the length between marks. For the rails PLM–2 (special) there shall be chosen heats of hard steel, giving at least 80 kg per square millimeter of ultimate strength (tensile resistance as defined above), but with an elongation which may be of 10 per cent only.

Rejections.—If one of the tests indicated in the above has not been passed, it shall be repeated on three new rails taken from the same lot as the first, and if any one of these latter fail to pass the test the whole lot shall be rejected. But in any case the whole heat shall be rejected of which any specimen has failed to meet any one of the tests prescribed.

Supervision of the Manufacture.—The supervision of the manufacture shall be done at the factory by one or several agents of the company, who shall remain there during the time of the manufacture of the rails, and to these agents the permission shall be given to exercise day and night the surveillance and make the verifications necessary to obtain the assurance that the conditions set for the manufacture as above indicated are being exactly fulfilled. They shall always have access into all of the places where the manufacture is being carried on.

The agents may address their observations to the superintendent or manager of the plant or to his representative, and not to the workmen or foremen (contremaîtres).

Provisional Acceptance.—(Omitted.)

Guarantee.—The acceptance at the factory is not final. The rails may be inspected anew at the place of destination. Moreover, all of the rails which in transport, during or before the laying of the same, shall break or deteriorate, for whatever cause it may be, shall be rejected.

The guarantee shall have a duration of six years, counting from the date of the manufacture; in the case that the rails are destined for a line of construction of which the opening shall be delayed, the length of the guarantee period shall not be less than three years from the date of the opening of the line in which the rails are laid.

The guarantee extends to all rails put out of service or deteriorated for any reason other than that of ordinary wear, with the exception of rails altered in an accident, duly noted.

(Articles 23 to 34 are here omitted, dealing with indemnities, final acceptance, delivery, penalties, payment, etc.)

SPECIFICATIONS FOR STRAIGHT STEEL AXLES FOR LOCOMOTIVES AND TENDERS (1906, 1908)*

Where specifications differ from the Paris, Lyon & Mediterranean Railways specifications for axles for carriages or freight cars, they are given below.

Manufacture.—The ingots shall be of basic Martin steel. The company reserves the right to use acid steel if guaranties of the quality of the charges of scrap used in the charges are given.

Testing—Taking of Samples.—The axles are grouped in lots of 25, all of which must be from the same heat.

Drop Test on the Body of Axle.—The first three blows are calculated from the formula $PH = 0.26\ D^2$; the second group of three blows, from the formula $PH = 0.30\ D^2$.

SPECIFICATIONS FOR STEEL AXLES FOR CARRIAGES AND FREIGHT CARS(1905, 1908)*

Identical with those of the Eastern Railways.

SPECIFICATIONS FOR STEEL TIRES FOR LOCOMOTIVES, TENDERS, CARRIAGES, AND CARS (1910)*

Identical with those of the Eastern Railways (MP 21).

SPECIFICATIONS FOR IRON OR STEEL WHEEL CENTERS, WITHOUT RIBS OR SPOKES (1904, 1912)*

Where differing from those of the Eastern Railways (41 MP), specifications are given below.

Tolerances.—In weight for rough wheels, −3 or +4 per cent; for rough finished or finished, −3 or +3 per cent.

SPECIFICATIONS FOR WHEEL CENTERS, WITH WELDED SPOKES OR RIBS (1904, 1912)*

Where differing from Paris, Lyon & Mediterranean Railways specifications for single plate nonribbed steel wheel centers, specifications are given below.

CLASSIFICATION.—Wheels of iron or of steel (acier soudé), rough, machined, or finished (ébauchés ou finis).

They may be (1) of simple spokes, (2) of double laminated spokes, (3) plates with ribs.

MANUFACTURE.—The welds shall be perfectly made.

2. **Tests—Nature.**—The tests shall include welding, quenching, and bending tests on samples (for steel only).

No analysis for phosphorus is required.

There shall be made on every 50 pieces two tests of weldability, quenching, and bending.

TAKING OF SAMPLES.—These shall be taken from the parts least damaged by the resistance tests on whole wheels. (See Paris, Lyon & Mediterranean Railways specifications for cast-steel wheel centers.)

WELDABILITY (ONLY FOR STEEL-WELDED WHEELS).—The samples shall have a cross section of about 15 to 25 mm by 40 mm and be about 250 mm long.

The specimens are broken and welded together in a lap weld in two heats.

QUENCHING TEST.—The specimen is heated to about 700°C, and quenched in a large volume of water. After cooling it is bent over a mandrel whose radius is equal to the thickness of the specimen.

Similarly the welded piece is bent at the weld until it forms a U with an interior distance equal to the thickness of the specimen. These bends must be made without rupture or cracking.

These tests are carried to destruction in order to examine the grain of the fracture which must be sound.

RESISTANCE TESTS ON WHEELS—(1) *Bending.*—The amount of bend must be for spoked wheels, 1 per cent, and for ribbed wheels, 1.5 per cent. There shall be no evidence of failure at any point of the wheel during this test.

(2) *Expanding Test on Hub Bore.*—The amount of expansion must be 3 per cent.

SPECIFICATIONS FOR CAST STEEL WHEEL CENTERS (1905, 1912)*

Specifications differing from those of the Eastern Railways are given below.

Manufacture.—The material may be of Bessemer, Martin, or crucible steel.

SPECIFICATIONS FOR TENDERS (1912)*

Wheel Centers.—The forcing of centers on to axles is to be done in the presence of an agent of the company. This is done gradually, by means of a hydraulic press, and shall take about five minutes. The end pressures shall be between 40 000 and 120 000 kg.

Shrinking of Tires.—This is done after axle forcing. The tire may not be heated above a dull red for this purpose.

Hammer Test of Tires.—The tires after mounting are struck with a 8-kg hammer while rotating, whereby the sound must be uniform and clear from all parts.

INSTRUCTIONS FOR THE MAINTENANCE OF MOUNTED AXLES, WHEELS, AND TIRES NO. 717 (1908)*

Principles applied in the upkeep of axles, wheels, and tires.

3. Axles are withdrawn from service (1) when fissures or transverse cracks show, (2) because of presence of longitudinal cracks, (3) when the diameters of journals or cranks are reduced by 6 per cent or the length of journal by 10 mm.

(*a*) Wheel centers are withdrawn when (1) two rim fissures appear, (2) one fissure or more in the spokes, (3) reduction in thickness of rim of 5 mm.

(*b*) Wheel centers with cast hub: (1) Two fractures at rim, one in a spoke or a reduction of thickness of the rim of 5 mm, (2) deformation of spokes or fissures in same.

(*c*) Wheel centers without ribs: (1) More than three fissures at the rim, (2) more than two radial fissures form in the plate (bracket).

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BELGIUM

STATE RAILWAYS †

SPECIAL SPECIFICATION[15] SHEET NO. 220 (1906)

The following are the laws, regulations, and specifications covering the processes of manufacture and methods of inspecting and testing of rails:

(Paragraphs dealing with contractual details, penalties, etc., are omitted.)

Shape of the Rails.—The rails must present the exact shape of the stamped templet (which has been given to the contractor as a model). The form of the rails must be strictly kept the whole of their length and especially at the ends, where care should be taken to avoid distortion at the time of cutting.

The places where the tie-plates are to be put must be perfectly smooth at the shoulder and at the base. A pattern, which gives the form of the plate, must be attached without delay. The end pieces of the joints (congés de raccord) must have exactly the measurements indicated in the plan.

Length of the Rails.—The normal length of the rails will be 18 m, and at the most one-fifteenth of the tonnage may be ordered in rails of 17.88 m in length.

(A paragraph dealing further with the lengths of rail to be furnished is here omitted.)

The tolerance in regard to the established lengths must not exceed in any case 1.5 mm more or less.

Weight of the Rails.—The normal weight of the rails is 50 kg per meter (in the case of secondary lines) and 57 kg (in the case of trunk lines having a fast running time.)

In the case of partial lots a tolerance of 2 per cent, more or less, will be allowed on this weight, provided that the total amount of the supply is not more than 1 per cent less or more than the normal weight. Within this tolerance and below the rails are to be paid according to their real weight. When the weight is more, the contractor will not be paid for the excess weight.

The rails having weights outside of these limits may be rejected if the inspector deems proper.

For each lot accepted the weight per meter shall be calculated from the weight as determined of at least 50 rails of normal length, taken in different heats, and chosen half by each contracting party.

Marks of the Rails.—The rail must bear on the two faces of the web, but not opposite each other, the distinct mark of the factory or mill of the contractor, the date of the year of the contract, and the letters A B or A T, according to whether the rails are of acid Bessemer or Thomas steel.

These marks must be made by engraving in the hollow or groove of the rolls.

They must be as plain as possible without hindering, however, the putting on of the tie-plates.

The rails must also have a number imprinted hot which will change with the heats and which will be of use in distinguishing the rails coming from the same or from different heats.

The letter T must be imprinted hot after the number of the heat on all the rails coming from the upper part of the ingots of metal.

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[15] These specifications concern the delivery of Vignole steel rails of normal weights of 40.65 kg per meter. However, the weights have since been changed to 50 and 57 kg per meter.

The Finishing.—The rails must be perfectly straight the whole of the length without any leeway. They must be straightened hot on leaving the rolling mill with the greatest care, so as to reduce as much as possible the amount of cold straightening. This must be done without impact and by gradual pressure.

All the rails must be milled at the ends so as to present a perfectly clean section perpendicular to the axis. The milling burrs shall be carefully removed, and no trace of cutting hot shall be visible. (Paragraphs follow dealing with the position of the tie-plate holes, and which are here omitted.)

Ingots, Metal, Tests, Marking.—The ingots must be able to make at least two rails of normal length (18 m).

The discards at the two ends of the ingots must be such that the fractures made near the ends of the rails will not show any traces of cracks or cavities or any other defects.

The rails must be of hard and tough steel. The fracture must show a material of fine grain, compact and homogeneous, free from white points, and coarse crystalline areas.

Tests of Rails.—The administration will receive only the rails which can pass the following tests. (The numerical values of the following tests apply to the rails of the weight 40.65 kg per meter):

1. In the case of each heat the impact test will be made by the commission as described here below on part of a rail about 2 m long having been stamped on the web, when hot, with the number of the heat to which it belongs.

This piece of a rail must be taken from the upper part of the ingot. (*It must not then be cut hot except on one end.*)

Each rail piece resting on the base on two supporting points 1.10 m apart must support the shock of a weight of 500 kg falling from a height of 4 m at the center of the span.

The two supports for this test must be of cast iron resting on an anvil of about 10 000 kg, which is on a foundation of masonry of at least 1 m in thickness and resting on solid earth.

The whole base must not suffer any perceptible deformation under the action of the weight.

If a break in the rail takes place, two whole rails of the same heat and coming from the upper part of two ingots must pass the drop test, but from a height of 6 m instead of 4 m. (The letter T must be stamped when hot on all the rails of this class after the number of the heat.)

If one of these rails does not pass the test, all the rails marked T coming from this heat must be refused, and the drop test must be continued on the other rails of this same heat. If one of these rails is broken, the entire lot from that heat must be refused.

2. The commission will then take from the supply presented from one-half to 1 per cent of the number of rails, each rail taken coming from a different heat.

Half of the rails thus taken must bear the stamp of the letter T. A portion of about 60 cm in length must be cut from each one of these rails to be submitted to the tensile test under the following conditions:

The bars having a diameter of 16 mm in a length of 200 mm between marks, taken from the head of the extremity of the rail (bourrelet) (these test bars may in exceptional cases be taken from the rail discards of the top of the ingot; if the results obtained thus are not satisfactory, the tests shall be continued in conformity with the regulations just given), must have a minimum tensile strength of 70 kg per square millimeter, with an elongation which may not be lower than 10 per cent.

The metal must take a good quench, so as to be cut with difficulty with a file.

3. The other parts of rails in question which can be cut again in 5 m lengths must resist the drop test from 6 m under the conditions described above.

If one of the last two tests is not satisfactory, the tests must be continued on a greater number of rails, and if more than a tenth of all the tests by the tensile test or by the drop test do not give the prescribed result, the entire supply offered for acccptance must be refused.

4. Parts of rails of about 3 m coming from the heats which have given the *greatest* amounts of bending in the first test mentioned above, after being placed on the base on two supporting points 1.10 m apart, must support for five minutes a weight of 25 000 kg at the middle of the two supporting points without being permanently deformed.

5. Rails of the normal length or parts of rails of at least 3 m in length coming from heats which have given the *least* amounts of bending at the first test mentioned above, when placed on their base, must be able to be curved when cold, following a curve of a radius of about 100 m without crack or seam appearing at any point.

The heats which do not satisfy one or the other of these last two tests may be refused.

Besides the tests prescribed above the commission can use any other means of testing that it judges suitable. For example, it may have rails broken in the drop test or otherwise in order to be sure of the good quality of the steel, and of the satisfactory manufacture of the rail.

6. The tests must take place at the mill and at the contractor's expense by means of apparatus furnished by him. The commission may verify the exactness of this apparatus and reserves the right to proceed to tests at the contractor's expense at the place where it judges suitable, in the presence of the contractor, who has been duly summoned for this.

In case of his absence he can not bring any complaint in regard to the applying of the tests. Analyses or other tests at the laboratory at Malines may also be required. In this case the expense of transportation of the objects to be tested from the factory to the place designated in the bids as the place of shipment, shall be borne by the contractor. The contractor shall furnish without charge boxes and other objects necessary for the shipping of the test pieces to the agents of the commission, and also ends of rails to be sent for test. It is not permitted to the contractor to re-present for acceptance rails which have already been subjected to test.

The rails which have been received must be marked at the two ends.

Repairing.—It is expressly forbidden to hammer, heat, or file rails with the purpose of concealing the defects of manufacture. The rails which present traces of such fraud must be thrown away.

SPECIFICATIONS TYPE XX (1906)†

The laws, regulations, and specifications now (1912) in force in Belgium covering the process of manufacture and methods of inspecting and testing of wheels and axles for freight and passenger cars and locomotives were adopted November 8, 1906, and are as follows:

General Regulations Common to Purchase of Wheels and Axles and All Other Articles.—All articles presented for delivery must conform exactly to the models or to the indications of the plans which have been submitted. They must be made according to all the rules of that industry; they must be without defect and their completion must not leave anything to be desired. They may not be covered with any greasy material.

In order to avoid any damage in the course of transportation in the loading or the unloading, the parts of the axles must be preserved from all contact by covering them with solidly fastened planks or boards.

It is expressly forbidden to hammer, heat, file, or engrave parts which are to be furnished in order to conceal the defects of their manufacture. Every piece which contains anything of this kind will be refused.

Where it is possible, every article must have the mark of the person to whom the contract of supplying it was awarded and also that of the manufacturer, and if it is deemed necessary, the date of the approval of the contract or the number of the specification, according to the case as well as the final date of the time limit of the guaranty.

When the quality of the material to be used is not stated in special terms or by plans, materials of the best quality must be chosen.

Independent of the tests specified in the specifications or in the contracts, the commission appointed for the receiving of the goods can submit the articles to such tests as they may deem fit.

When a test has resulted unfavorably, the commission (Commission de Réception) may authorize a second test on the request of the contractor.

If the commission finds that 10 per cent of the articles presented do not satisfy the conditions agreed upon, they can refuse all of that contract of supplies. The manufacture of the axles, bodies of wheels, cranks, mainsprings (pivots), and of the mounted wheels can be made only in establishments approved by the Government.

SPECIAL REGULATIONS

Crank Axles for Locomotives, Locomotive Tenders, and Cars.—These axles must be of iron or steel at the choice of the contractor. The metal used must be of extra quality.

The axles must be completely finished; the bearing parts must be perfectly polished; the others must be painted white.

The bearing necks must be perfectly cylindrical and the greatest attention must be paid to see that they do not acquire in turning the least tapering in length; the hollows of the elbows must be made entirely and exclusively by a slotting machine.

In the case of models of axles whose cranks (pallettes) are shrunk on (frettées) the collars must be of No. 4 iron or of iron of the same kind which can be welded. The collars must be finished according to the indications of the plan in order to obtain perfect contact with the axle crank. No trace of calking will be tolerated.

The dimensions indicated in the plans must be rigorously observed.

Marks must be arranged as follows, placed in letters of a centimeter in height at the position marked C in the sketch (here omitted):

Name of contractor: Number of specification: Final date of guaranty:	Nature of metal: Name of manufacturer:

Straight Axles of Locomotives, Axles of Tenders, Passenger and Freight Cars.—The straight axles must be of steel of the very best quality. The kind of steel and the manner of manufacture are left to the choice of the contractor.

MARKS.—The marks to be applied must be stamped when hot. Each axle must present at the place given in the plans an oval or rectangular cavity 4.5 cm long, 1.5 cm wide, and 0.5 cm deep, which is to receive the marks of the temporary accepting, of the accepting, or of the refusal.

CONDITIONS OF MANUFACTURE.—The axles must be entirely finished according to the indications of the plans which have been given; the journals must be turned so that the center points of the extremities can be maintained. The axles of passenger cars must be entirely turned. The journal must be perfectly polished and cylindrical and have no scratches, cracks, etc.

TESTS.—The axles must be presented in series of 50. If the quantity to be furnished is equal to or less than 50, they must be presented in one delivery. For each series or fraction thereof a supplementary axle must be furnished which is to take the

place of the one designated for the impact test. This condition must be likewise fulfilled for the series of less than 50 axles which make up the balance of a contract. If the supply includes axles of different models, the contractor must add an extra axle for each of the models presented. No tests will be made until these conditions have been fulfilled.

The axles must undergo tests after their completion. They can, however, be presented and tested in the unfinished state on condition of being submitted again for the examination of the commission after completion. The transportation charges both ways, entailed in making use of this privilege, are to be supported by the contractor.

The axles can also be tested when in the rough condition as to the quality of the material and the manner of manufacture to be used in the shops of the manufacturer on condition that these shops are located in Belgium, but the examination of the parts as to defects and dimensions must always be made at the place where they are to be supplied.

The tests must be carried on as follows:

The commission for acceptance will commence by refusing axles bearing exterior defects such as cavities, defects in the welding, both longitudinal and transverse. The axles must be then grouped in series of 50. The commission must choose from each series an axle which, when placed on two supports 1.500 m apart, must withstand a blow of a hammer of a weight P falling from a height H determined by the following formula:

$$PH=0.00318\ d^3$$

P being the weight in kilograms, H the height in meters from which it falls, and d the diameter in millimeters of the middle of the axle.

If the axle breaks or shows cracks, the series to which it belongs must be refused.

If the contractor is not opposed to it, or if he expresses the desire, the commission can have the impact test made on the axles refused for defects other than failure to satisfy the physical requirements.

When the undertaking comprises the furnishing of axles of different models, the supplementary axles, for which a test will not have been deemed necessary, if they are free from exterior defects, must be delivered at the prices of the contract, in the case of axles furnished as exchange pieces delivered at a price to be determined according to the results of the former contracts, and if it has to do with axles entering into the composition of sets of wheels with axle attached.

Tires for Locomotive, Tender, Carriage, and Car Wheels.—The tires shall be of steel (of which the carbon content shall not be less than 0.30).[16]

DIMENSIONS.—The profile given shall be rigorously adhered to. A caliper shall be applied to the tire without delay; the shoulders and fillets shall have exactly the dimensions indicated in the drawings. The special specifications or order for the tires will indicate the profile and interior and exterior diameters desired in the tires.

MARKING.—The marks shall be put on hot at the place indicated. The tires shall bear the heat number, which is of a series beginning each year. Before the marking each tire must present on the said surface three rectangular cavities.

MANUFACTURE.—The tires shall be made of ingots, which have been forged under the hammer on all the faces, and not of billets (rondelles) which have only been rolled.

The rolling shall be as perfect as possible; the surface shall be smooth and free of surface defects, such as seams, fissures, etc., clean and smooth, and free from fins, cavities, lines, or other faults of any sort. The tires shall be perfectly plane without the least warping. The administration reserves the right to have the melting of the

[16] This specification omitted in 1912.

steel and the process of manufacture inspected by one of their agents, for which purpose they shall be advised two days in advance of the day and the hour of each melting or heat and of the time when the ingots will be put into the mill. The ingots shall be carefully grouped by heats, and shall bear, readily visible, the number of the heat from which they come. The manufacturer shall keep a memorandum of the production in ingots of each heat, of the weight of the ingots, of the result of the tests practiced at the plant, and of the number of the tires which he will have obtained. These memoranda shall be communicated to the engineer agents of the administration when they shall demand them; and the manufacturer shall carefully examine all ingots before proceeding further, and those having flaws, such as blowholes (soufflures), fissures, etc., or those coming from a heat adjudged defective shall be rejected.

The ingots shall be charged to the reheating furnaces cold, and care shall be taken that they may there be disposed in such a way that it may be immediately seen from which heat they come. All of the ingots from the same heat shall, when possible, be rolled together. Precautions must be taken in the course of the manufacture of the tires that the ingots, blooms, or tires coming from different heats may not become confused.

Testing of the Finished Product.—The commission will proceed to examine the surface of the tires, and should there be cause for the rejection, those showing scratches, cavities, cracks, transverse or longitudinal, shall be rejected. From among those sound in the above respect the official of tests shall choose one tire from each heat for test.

Drop test.—These tires shall be subjected to a drop test in which the weight of hammer and height of fall are determined by the following formulæ:

$PH=Kbe^2$.

P=weight of hammer.

H=height of fall.

b=width of tire.

e=thickness of tire at running surface.

K=constant for various profiles.

K=0.01257 for tires for locomotives and tenders, profile No. 1, method of attachment of the London-Chatham-Dover Co.

K=0.01106 for tires for locomotives and tenders, profile No. 2, method of attachment of the Alsatian Society.

K=0.01146 for tires for locomotives and tenders, profile No. 3, method of attachment of the Caledonian Railway.

K=0.01286 for tires for passenger and freight cars.

Nevertheless, it is permitted for the tires provided with the Caledonian method of attachment to use the following specifications instead of the above ones for the impact test.

"1. The tire must allow of a reduction under the press of one-sixth of the original diameter measured on the tread surface without fracturing or fissuring.

"2. The material must have an ultimate strength in tension of at least 71 kg per square millimeter, with an elongation of at least 17 per cent measured over a length of 0.508.

"The tires tested in the impact test shall be struck three blows, and at the end of the second one the reduction of vertical diameter shall not be greater than one-seventh of the original for tires of wheels for locomotives, tenders, freight and passenger cars. After the third blow the tire shall not fracture or show signs of fissuring. Otherwise the tires of that heat are to be rejected."

Conditions Common to all Tires.—The contractor is obliged to replace all tires tested in accordance with the contract covering the furnishing of tires in exchange. The administration reserves the right to submit each tire, after it has been mounted on the wheel, to tests with the hammer, made by hand or with special apparatus. The tires which do not pass these tests shall be rejected, and the tires returned to the contractor, who must replace them if the hammer test has been made in the course of the tentative or final acceptance of the wheel sets or pairs. If it is a question of replaced tires, the tires which shall not have passed this test shall be considered as having been placed out of service by the application of the conditions of the guaranty.

TOLERANCES—OVALIZATION.—An ovalization, or a difference between two interior diameters whatever, of the tires is not allowed except on the condition that the greatest interior diameter and the minimum exterior diameter remain within the tolerances indicated below. In any case the ovalization in the case of tires for wheels for freight cars is limited to 2 mm at the most.

EXTERIOR AND INTERION DIAMETERS.—There is allowed a tolerance of -2 mm in the interior diameter and of ± 2 mm in the exterior diameter. No tolerances are allowed in the other sense in either diameter.

WIDTH.—There is allowed a tolerance of ± 1 mm in the width of the tires.

(There follow further paragraphs dealing with the tolerances which are here omitted.)

Conditions Common to Straight Axles and to Tires.—When the drop test has resulted unfavorably, if the commission for receiving decides that there is reason for two tests, the second test will be on two axles or upon two tires. If this new test is favorable, the supply may be accepted.

In order to render account of the quality of the material used, the commission for receiving can break the axles and the tires which have been refused because of defects or because of tests, and the contractor can not claim any indemnity for this.

If the quality of the material is found to be bad, the lot may be refused even when the results of the impact test have given satisfactory results.

The axles and tires refused for the different reasons will be returned to the contractors after the placing of a mark of refusal by the commission for receiving, which will have the privilege of causing them to be shown at any time up to complete finishing of the contract.

The axles and tires upon which the tests have been made, being in every case considered as refused, will be charged to the account of the contractor.

Bodies or Centers of Wheels for Locomotives and Tenders.—The bodies of the wheels must be of wrought iron (fer forgé) or cast steel. When cast steel is used the words "acier coulé" (cast steel) must be marked in the casting on the outside face of the body of the wheel in letters 2 cm high and 2 mm in relief.

Bodies of Wheels in Wrought Iron.—The welding of the spokes of the hubs and of the outer rim of the wheels must be of perfect workmanship. The bodies of the wheels must come from the forge in good condition.

Bodies (Corps) of Wheels of Wrought Iron and Cast Steel.—The bodies of the wheels of this kind must be without defect; the spokes must be straight. The outer rims must be turned, and there must not be any spot which has not been touched by the turning tool. The hub must be turned on its vertical surfaces and its bore reamed in such a way as to be perfectly adapted to the wheel seat (portée de calage). The counterbalances must be cast or welded on and not be merely attached to it. The wheels with elliptical spokes are admitted on the same footing as wheels having rectangular spokes.

The physical properties of the steel wheel centers are as follows: Tensile strength, 40 kg per square millimeter; elongation for 200 mm test length, 15 per cent. The bodies of the wheels must be marked on the hub.

Bodies or Centers of Wheels for Passenger and Freight Cars.—The bodies of wheels for passenger and freight cars must be one of the types which figure in the plans which have been given.

No leeway will be allowed in regard to the diameter of the rim of the wheels nor in regard to the interior diameter of the hub.

The body of the wheels must be of wrought iron or steel. In case cast steel is used the metal must have a tensile strength of 40 kg per square millimeter, with a minimum percentage of elongation of 10 per cent, the tests being made on bars 200 mm long.

The marks and the gauge measurements must be made under the care of the contractor, but under the inspection and according to the indications of the delegates of the commission of delivery.

Sets and Pairs of Wheels.—The special conditions imposed upon the elements forming parts of the sets and pairs of wheels have already been given above.

(Beginning below, with the paragraph headed "Placing of the wheels upon their axles," the text is not complete, as the original contains much matter which is irrelevant to the present purpose.)

Placing of the Wheels Upon Their Axles—General Conditions.—The tires must be put on hot and must fit perfectly. The fastening must be obtained by a decrease of the inside diameter of the tire in connection with the outside diameter of the outer rim of the wheel.

This decrease must be 1 mm per meter of the exterior diameter of the outer rim of the wheel.

The wheels must be placed quite symmetrical to the axis of the axle journal. The two tires of the same pair of wheels must have the same exterior diameter. The fastening of the tires on the wheels must be done with the greatest care.

The contracting parties must produce an official report showing the pressure in kilograms with which each wheel has been put on the axle. This report must be drawn up so that later, at the time of furnishing, the pressure at which each one of the wheels has been put on can be easily verified. This report in regard to the pressure does not prevent the commission for receiving from proceeding to tests.

Wheels of Locomotives and Tenders.—The cranks can be put on the axle by pressure hot or cold, at the choice of the constructor. This operation must be done with the most minute care under the guaranty of the constructor.

The cranks of the same pair of wheels must be placed exactly square the one as regards the other.

The application of the wheels on the axles must be made by hydraulic press under a pressure of at least 80 000 kg. However, this pressure of application is 60 000 kg for wheels of locomotive tenders, type 11; 70 000 kg for axles of bogies of locomotives, types 15, 17, and 18; 85 000 kg for axle motors and couplings of locomotives, types 15, 17, 18, 30, and 32.

Wheels of Passenger Cars and Freight Cars.—The wheels must be applied on the axles with heavy friction.

The pressure of application must be at least 40 000 kg for the sets of wheels with axle journals of 225 by 130; it must be at least 35 000 kg for sets of wheels with axle journals 170 by 97, 205 by 110, and 242 by 120; it must be at least 30 000 kg for sets of wheels with axle journals 150 by 80.

The application pressure must be at least 80 000 kg for sets of wheels with axle journals 180 by 130 of braked vans, baggage cars with chassis in cast iron. The commission for receiving cars, if it judges suitable, may have a certain number of the wheels of the supply to be furnished demounted. The supply will be refused if the pressure required for putting the wheels on again at the test does not come up to 80 000 kg, 40 000 kg, or 30 000 kg, according to each category.

Pairs of Balanced Wheels for Passenger Cars.—Besides the conditions which have preceded, the pairs of balanced wheels must fulfill the following conditions:

WHEEL CENTERS.—The centers of the wheels must be carefully turned according to the indications of the plans which have been given. The interior surface of the hub of the wheels and the outside surface of the rim must be strictly concentric; any eccentricity is not allowed. After finishing the wheel centers must be weighed and the indication of the weight of each one of them must be imprinted on the outside face of the hub. The balancing weight (balourd) must then be verified by means of an axis perfectly centered engaging the hub and resting on two horizontal supports. Every wheel center whose balancing weight measured at the rim shall exceed 0.5 kg will be refused.

Each center will receive then on the inner surface of the rim the indication of the value of the balancing weight at the exact spot where it has been ascertained. The observing of these regulations must be established prior to putting on the axle by a mark of temporary receiving.

The Mounting of the Centers of the Wheels.—The axles must be completely turned. The tires must be turned on every side to the dimensions indicated in the plan which has been given.

The centers of the wheels must be mounted on the axle so that their respective balancing weights (balourds) are in the same plane passing through the axis and on the same side of this axis so that they join each other.

The sum of these balancing weights (balourds) must not exceed 0.750 kg. The center of gravity of the whole system must coincide with its central axis; that is to say, the set of wheels being suspended by the middle of the axle, the axis of this latter must rest in equilibrium in a horizontal position.

The position of equilibrium can, however, be established at the time of receiving by means of a weight suspended in the middle of the axle journal. This weight can not exceed 1 kg. The conditions of equilibrium imposed upon the pairs of wheels unprovided with tires must be fulfilled the same as when the sets of wheels are furnished with their tires.

The following are considered as being unfit for service: Parts which break, tires which are only 30 mm thick at the center of the section, tires which become loose in service, and, finally, any part which is in such a state which will endanger the security of service.

The guarantees are as follows:

	Years.
Wheel centers for passenger and freight cars	2
Axles for passenger and freight cars	3
Tires for passenger and freight cars	3
Crank axles	3½
Wheel centers for locomotives and tenders	4
Straight axles for locomotives and tenders	4
Tires for locomotives and tenders	5

SPECIFICATIONS (SPECIAL) NO. 1439 (1913) †

Modifications in Regulations and Conditions Regarding Crank Axles for Locomotives.—The special conditions in the specifications, Type XX, approved November 8, 1906, were modified and completed as follows:

The crank axles for locomotives must be of nickel steel; this steel must have a minimum tensile strength of 60 kg per square millimeter.

The minimum elongation percentage must be 18 per cent on a length between points 200 mm apart and the minimum reduction of area (striction), 45 per cent, the diameter of the specimen being 20 mm. The specimens must be taken in the pro-

longation of the crank axles and in a longitudinal sense. Placing a mark at the extremity of each axle will be sufficient for this.

The reduction of area must be understood here as being the proportional reduction of a section of the test piece. It is expressed in millimeters by the formula:

$$\frac{A-a}{A} \times 100$$

in which A represents the original section and a represents the section of fracture.

Among the marks this steel must be marked by the letter N to distinguish the nickel steel from the ordinary steel.

GUARANTIES.—The furnishing of sets of wheels or pairs of wheels of straight and crank axles, of centers of wheels, etc., subject to guaranties as to length of time of service.

The contractor is notified when the guaranty commences, either when the contract has been approved or at the time of the order.

The commission for receiving condemns parts found to be defective during the time of the guaranty.

SPECIAL SPECIFICATIONS FOR LOCOMOTIVES (1907)*

Cast Steel.—Cast steel shall have an ultimate strength in tension of at least 40 k per square millimeter with an elongation of at least 15 per cent on a length of 200 mm. When the elongation can not be measured on a greater length than 100 mm it shall be at least 18 per cent. All pieces of cast steel shall be perfectly annealed.

Axles and Straight Axles.—For each series or fraction of a series of 50 axles there shall be furnished an extra axle for test purposes. (Identical with specification, Type XX.)

Wheel Bodies and Centers.—(Identical with Type XX of specifications.)

Crank Axles.—(Identical with Type XX of specifications.)

Guarantees.—Wheels and their constituent parts are guaranteed for the following periods:

	Years.
Straight axles	4
Crank axles	3½
Wheel centers	4
Tires (furnished to the contractor by the administration)	2
Tires (furnished by the contractor)	5

GERMANY

COMBINED PRUSSIAN AND HESSIAN STATE RAILWAY ADMINISTRATION

SPECIAL REGULATIONS FOR THE DELIVERY OF RAILS AND TONGUE RAILS (1912)

1. **Kind and Properties of the Material.**—(1) The rails shall be manufactured of soft steel (Flussstahl); the method of manufacture is left to the manufacturer; it must, however, be given in the bids.

(2) The material of the finished rails must be tested according to the special regulations for the testing and acceptance of materials and those of paragraph 6 for strength and toughness. The criterion of the strength shall be tensile and compression tests, of toughness, the drop test.

(3) The ultimate strength in tension must be at least 60 kg per square millimeter of original cross section. In the compression test the penetration of a ball of 19 mm diameter shall be not more than 5.5 mm and not less than 3.5 mm, with a pressure of 50 000 kg. In the drop test the rails must stand the following test:

A span of 1 m of a rail with the head lying up shall be able to bend at least 100 mm at the center under the blows of a hammer tup at the center of the span without breaking or showing flaw of any kind. The tongue rails must, under the same conditions, bend 130 mm.

2. **Manufacture and Quality.**—(1) The rails must be rolled out accurately according to the drawings and the templet made from them. The templets must be stamped with the stamp of the railway administration, in order to show that they have been compared with the original templet at the administration's central office in Berlin, if they do not already bear the stamp of the earlier Cologne railway administration at Essen. The contractor may buy the necessary templets from the railway administration, and is, however, obliged to have the correctness of the same tested by the railway administration testing agent before the rolling is done. In acceptance of rails only templets which have been compared with the original one may be used.

(2) Variations in the height and head width of 0.5 mm are allowed, in the base width, of 1 mm.

(3) The rails may not be heated after being rolled. A little cold straightening is permitted; this must, however, be done carefully in the straightening press with nonimpact pressure, and neither the supports or the stamp may leave marks on the rails in the process.

(4) The finished rails must not be warped nor show flaws, such as fissures or seams.

(5) Hammering or welding up fissures and similar attempts to cover up flaws are particularly forbidden. The chiseling off of fins, etc., is only allowed when they are not greater than 1 mm and are not located at the ends of the rail or the upper, rounded edges of the head.

(6) The machining of the ends is only to be done with circular saw or milling machine. The surfaces must be perpendicular to the longitudinal axis of the rail. In the case of rails with scarfed joints the depth of the cut must be accurately adhered to.

(7) The rails must be provided with the holes shown in the sketch, which are to be bored. The close-up rails shall be characterized as such by holes of 20 mm diameter in the web at one end.

(8) The burr caused by the machining is to be carefully removed.

3. Length of the Rails.—(1) The rails are to be furnished according to demand in the lengths given in the drawing and which are as follows: (A long table dealing with the actual lengths is given here, which is not reproduced. The lengths vary from 12 to 18 meters.)

(3) The contractor is obliged to furnish upon demand a certain fraction of the total weight of the rails in shorter lengths, which fraction is to be definitely settled in the contract. The contractor is, however, entitled to demand that the delivery of the shorter rails be made as far as possible at the same time as that of the rails of normal length.

(4) On the other hand, the contractor may require that in the case of rail types 6, 7, 8, 9, 15, and 16, at least 6 per cent of the total weight shall be ordered in lengths which are at least 0.5 m less than normal. He is, on demand, obliged to furnish the half of this 6 per cent in the case of the rail types 6, 7, 8, and 9, in lengths of 10 m or other proper length, constant for the whole half, while the shorter lengths of the rail types 15 and 16 are to be all 12 m.

(5) In the case of tongue rails the furnishing of lengths shorter than those specified by the administration is not permitted.

(6) Rails up to 9 m in length are allowed a tolerance in length of ± 2 mm, those over 9 m a tolerance of ± 3 mm.

4. Weights of Rails.—(1) (The weights of types of rails are given; here omitted.)

(2) The following method is used for the determination of the weight of rails for which payment shall be made:

(*a*) The weight of the finished and accepted rails is determined by weighing at the plant of the contractor, and under the direction of the inspector, 5 per cent of the whole lot for delivery. The average weight found in this manner shall be taken as a basis for the price calculation.

(*b*) The weights should be as follows: (A table is given of the weights, which are theoretical; here omitted.)

(*c*) A tolerance of ± 3 per cent and -2 per cent is allowed in the weight, and overweight will be paid for up to 1 per cent; in all other cases the actual weight will be paid for.

5. Marking.—(1) Every rail must bear the manufacturer's mark and the year of intended installation on the web.

(2) The marks are to be made in accordance with the sketch.

(3) Rails of lengths other than those given in article 3 are to be marked with white paint on the two ends. The lengths of these rails are also to be painted on the web at the tie-plate holes, in white.

6. Testing.—(1) In order to determine to what degree the finished rails satisfy the conditions of paragraph (1), lengths of rail 1.3 m long shall be chosen in which there are no track bolt holes or notches, and drop tests shall be carried out on these. In these tests equal blows of 1500 kgm impact work shall be applied until the rail piece has been bent the amount required in section 1.

The last blow can be made with an energy suited to the bending to be accomplished. The temperature of the test piece is to be determined and noted. In the case of about one-third of the test pieces the test is to be carried to destruction; if necessary, the rupture is to be brought about by notching. Unusual phenomena in the mode of deformation of the test piece and of the mode of fracture are to be investigated as far as possible and noted.

(2) Tensile and compression tests shall then be carried out with the test pieces from the impact test; for the tensile test, test pieces, of the form and shape shown in the drawing (this sketch was not included in the specification and can not be here reproduced, but attention is called to the general form of tensile test pieces shown on p. —) shall be taken from the center of the head of the least bent part (cut out

cold) and tested in the tensile machine. Besides the ultimate strength, the elongation and the reduction of area shall be determined.

(3) The official making the tests is empowered to choose from each 200 finished rails, or in case of delivery of a smaller number, from each smaller lot, one rail, which is to be subjected to the above-mentioned tests. One half of such rails are to be tested in tension and the other half in compression.

(4) If the test rail fulfills only in part or not at all the specifications given above, a second, and even a third, rail shall be chosen from the same heat and tested. Each of these rails is to be subjected to the tensile and to the compression test. If either one of these last rails fails to meet the requirements of the test, the heat will not be accepted. For the purpose of these tests all rails must bear on the web the number of the heat.

(5) If in the further tests of these rails the impression is gained that the material is faulty, and if in their inspection flaws or other evidences of inferiority are found, the lot may be rejected. In these cases the appropriate clauses in the contract apply in the consideration of delays or damage which may ensue as a result of such rejection.

(6) Those rails accepted by the official of tests are provided with the acceptance stamp and are suitable for delivery. Unstamped rails may not be accepted unless the testing and the acceptance take place at the same place.

7. Guarantee.—(1) The guarantee provided in the general contract clauses for the furnishing or contracting begins with the acceptance and ends after a period of five years, reckoning from the end of the year of intended installation or laying of the rails as indicated by the date rolled on the rail.

(2) In the case of tongue rails the guarantee extends only to the replacement for those rails, which in the course of working or machining are shown not to be according to specification, because of unsound material or because of faulty manufacture. The guarantee period ends on December 31 of the year following that of the final acceptance of the rails.

(3) The fulfillment of guarantee on rails, which fail during the guarantee period, is made by cash settlement on the basis of the table of weights of article 4. The replaceable rails shall be ceded to the railway administration at a scrap price of M 65 per (metric) ton, as long as the number of such from any one plant in any one railway division (Bahnmeisterei) is not greater than three in one year.

(4) The application for the fulfillment of the guarantee is made through that division of the administration, in which the failed or defective rails are found, whereas the payment is settled through that division in which the contract was made.

SPECIAL REGULATIONS FOR THE DELIVERY OF PARTICULARLY HARD RAILS (BESONDERS VERSCHLEISSFEST) (1912)

These are the same as for other rails with the exception of the following clauses:

(3) The ultimate strength in tension shall be at least 70 kg per square millimeter. In the hardness tests the penetration of a ball of 19 mm radius shall be not greater than 5 mm and not less than 3 mm, with a pressure of 50 000 kg.

In the impact test a span of 1 m of the rail lying with the head up must stand the blows of a hammer tup in bending 80 mm at the center before the failure occurs.

7. Guarantee.—(1) The period of guarantee (defined in the same way as for ordinary rails) is seven years. The guarantee extends also to rails which, before the end of the seven-year period, show in the middle part of the rail more than 4 mm wear in the height, or at the ends, an amount of wear, which is more than 1 mm greater than that in the middle of the rail, and further to rails in the case of which, because of too great wear of the rail ends, the tie-bolts do not fulfill their function. When the necessity for recovery on these latter rails occurs before the end of a period of five years, only the price increase (contractual) for the longer guarantee period and for the greater tensile strength is to be paid. If this necessity occur only after the

end of five years and before the end of seven years only the price increase for the longer guarantee period is to be paid.

PRUSSIAN STATE RAILWAYS ADMINISTRATION

REGULATIONS FOR THE QUALITY AND TESTING OF MATERIALS FOR ROLLING STOCK (1908)†

Quality—General.—The materials for rolling stock, in regard to their quality and mode of manufacture, shall correspond to the following conditions: The least values of the tensile strength are to be understood as those loads in kilograms per square millimeter of the original cross section, which the test piece will bear; the least value of the elongation, as that fractional part of the original test length, as prescribed below (and in the drawings), by which the test length is increased after fracture. The test length shall be 200 mm whenever possible, and not otherwise prescribed. The specifications for tensile strength and elongation hold no matter whether the material has been formed by forging, pressing, rolling, or casting.

3. STEEL (FLUSSSTAHL).—The steel must be tough and of homogeneous structure.

(*b*) The tensile strength of steel, acid or basic, Martin, Thomas, or Bessemer, for axles and tires shall be at least 50 kg per square millimeter; for locomotives and tender tires (Martin steel), at least 60 kg per square millimeter. As a test of the toughness a drop test shall serve (see below). The tires must be shrunk on to the body of the wheel with a shrinkage of 1 mm for every meter of inner diameter, without tearing or showing any flaw which could be ascribed to the material or the process of manufacture.

(*e*) *Crucible Steel for Tires.*—This material must have a tensile strength of at least 70 kg per square millimeter. A drop test shall also be carried out.

(*g*) *Nickel Steel for Axles.*—The material for locomotive crank axles must have a nickel content of 5 per cent and that for axles up to 120 mm in diameter, one of 2 to 3 per cent. The tensile strength shall be at least 60 kg per square millimeter and the elongation 18 per cent, the reduction of area at least 45 per cent.

4. CAST STEEL.—The cast steel must be tough, dense, and quite homogeneous in structure.

The cast piece shall be clean, full at the edges and corners, and may contain neither fissures nor pipe. The coupons and risers must be carefully removed. Sharp-cornered shoulders are to be avoided.

The tensile strength must be at least 50 kg per square millimeter and not more than 60 kg per square millimeter, with an elongation of at least 16 per cent, which may be taken over a test length of 100 mm.

5. SOFT STEEL (FLUSSEISEN).—The tensile strength may not be more than 50 kg per square millimeter. The steel must possess a homogeneous structure, must have taken cleanly the desired form, rolled out full-edged; it may have no flaws, such as cracks, seams, or holes.

(*c*) *Soft Steel for Wheel Plates.*—The tensile strength may be between 40 and 50 kg per square millimeter. A drop test shall be the criterion of its toughness.

6. CAST SOFT STEEL (FLUSSEISENGUSS).—The cast steel shall be tough and of homogeneous structure throughout. The casting shall be clean and full at the edges and corners and may contain neither fissures nor pipe. The coupons and risers shall be carefully removed. Sharp-cornered shoulders are to be avoided. The tensile test shall serve as a criterion of the strength and the elongation; the drop test, in the case of certain cast forms (wheel centers), as a measure of the toughness. The elongation may be measured on the original length of 100 mm. The annealing of the test pieces is not permitted unless the casting is also to be annealed. Over a test length of 100 mm the tensile strength shall lie between 37 and 44 kg per square millimeter with an elongation of at least 20 per cent.

7. WROUGHT IRON.—This must be of fibrous structure, dense, easily forgeable and weldable, neither hot nor cold short, and must be free of flaws, slag, blowholes, seams, etc.

Tests.—1. GENERAL.—The materials are, as a rule, to be tested before use in the plant of the contractor or subcontractor. If the testing of the materials is done at the request of the contractor, not in his own, but in the plant of his subcontrator, he must pay to the Government the costs caused thereby, such as wages of the inspector and traveling expenses, etc.

The parts which are according to specification are, as a rule, stamped with the test stamp, which should be made easily visible by marking over or near it with white paint.

The material to be tested must be treated in just the same way as all of the material for that lot which is represented. After the selecting and marking of specimens for test these may not be afterwards annealed. (For exception in the case of wheel tires, see par. 2 under 4.) Therefore the test pieces chosen by the inspector are to be cut out cold and cold machined. Every test specimen must be distinctly stamped and numbered and be taken from parts or articles which have the same dimensions and have been manufactured and treated in the same way as the others of the same lot. (Some paragraphs relating to sheet metal and wood are omitted.) The railway administration reserves the right to have tests carried out on material in its own shops or in those of any plant which is near, besides those carried out in the shop of the contractor. If there is in the plant of the contractor or furnisher no apparatus for the testing of materials, the testing of the materials must be done at the cost of the contractor in a railway shop. For such tests the articles or parts to be tested and the test pieces for the tensile test, the latter in duplicate, must be sent prepaid to the indicated railway shop. These test pieces must be machined and in the form suitable for test; if not, they will be machined in the railway shop at the expense of the contractor.

From those test articles and pieces tested at the shops of the contractor sample and fractured pieces must, at demand, be sent prepaid to the administration. The contractor is, however, not obliged to preserve these longer than three weeks. No damages will be paid for articles which have been rendered useless in the course of testing.

2. EXTENT OF THE TESTS.—The official of tests is empowered to choose one of every 50 (or part thereof) locomotive, tender, or freight-car axles, wheel tires, or other parts of rolling stock for purposes of testing.

In the case of crucible steel tires, one of every 25 (or part thereof) may be tested; if the test piece chosen fails in the test, the whole lot or part thereof shall be rejected, unless in the judgment of the inspector some local and unimportant fault was responsible for the failure of the tire chosen, in which case two others will be chosen, and if either of these do not fulfill the specifications, the lot must be rejected.

The soft steel cast wheel centers are all to be provided with test coupons, out of which tensile test pieces may be taken. The inspector may take from every 10 wheel centers one tensile specimen, and, further, from every 50 wheel centers, or part thereof, one may be taken for the drop test. From the parts of the latter test specimens may be taken for the study of the homogeneity of the metal.

Those axles, or tires, which are from the same heat must be kept separate until the tests are concluded, and the contractor is obliged at any time to state which of them belong to any one heat.

The tests of axles and tires are not to be begun until the list of the heat numbers has been given to the inspector.

If test pieces fail to meet the tests, then the pieces from that heat must all be rejected.

If the official of tests gets the impression that failure to meet the tests is due to insignificant local flaws, two further test pieces may be chosen from the same heat for test, which must both meet the requirements.

Before taking the second and third specimens, the whole lot of the respective heat may be annealed. If only one of these fail to meet the tests, the articles from that heat must be rejected.

In case small variations are found from the required conditions, and the inspector believes that an error of measurement may explain these, it is permitted to make not more and not less than two further tests to ascertain whether the material is fit for acceptance or not.

If in further tests the inspector is not convinced of the faultless quality of the material, or other defects or faults appear during the inspection or acceptance which indicate the defective quality of the material, the railway administration may reject the whole lot. For damages which arise from this reason or because of delay in the furnishing of the articles to be inspected the regulations of paragraphs 7, 10, and 12 of the general contract regulations hold.

3. DROP TESTS.—(*a*) *Construction of the Drop-Testing Machine.*—The machine must have such a height that an impact work of 5600 kgm is possible.

The base must be of masonry, of which the size is limited by the building conditions but which must be at least 1 m deep.

The supports for the test piece must be fastened, wedged, for example, to a cast-iron base of one piece resting on the masonry construction and which weighs at least 10 000 kg.

The tup guides shall be of metal, for example, rails, and shall be so constructed that no great side play is possible. It is recommended that the guides be lubricated with graphite. The center of inertia of the tup must lie in the center line of the guides and the ratio of the guide length of the tup to the inside width of the tup must be greater than 2 to 1. The form of the tup is to be chosen such that the center of inertia lies as low as possible. The mass of the hammer may be of cast iron, cast or forged steel; it is to be fastened with a coupling device to the tup holder symmetrically to its center of inertia; the fulfillment of this condition shall be made recognizable by special marks. The striking face shall be rounded with a radius of not less than 150 mm, and the striking line shall be perpendicular to the center line of the hammer. The weight of the tup shall be 1000 kg, but if this is not possible, it shall be as near as possible to 500 kg. The clutching device shall be of such form that it does not hinder the free fall of the tup and will prevent the accidental falling of the same.

A device must also be installed to prevent the complete fall of the hammer in case it is accidentally released, and which will protect persons engaged at the machine from injury.

The graduation of the upright guides in meters and decimeters must be possible of vertical displacement and easily visible to the observer.

In the case of drop tests with wheel tires the tup shall strike upon a piece of at the most 20 kg in weight, which is plane above and corresponds below to the profile of the tire. The tires shall be supported in the correct position for taking the blow.

The supports for the axles shall be half cylindrical, saddlelike form of half radius of 50 mm. Devices must be used to prevent the flying out of axles or tires when struck; such devices must not affect the deformation caused by the blow.

The contractor is obliged to furnish a sketch of the machine used to test his materials at the demand of the railway authorities, and to give the inspector an opportunity to test its correctness.

(*b*) *Drop Tests With Axles.*—The axles to be tested may be either rough or machined; in the test they are to be supported on supports with a span of 150 cm, and struck in the center of the span. Locomotive axles must withstand eight blows of 5600 kgm and tender axles the same number, of 4200 kgm impact work. After each blow they are to be turned over.

Car axles of 145 mm wheel-seat diameter shall, with blows of 3000 kgm each, bend 180 mm at the center without any signs of failure, while those of 130 mm diameter must bend in the same way at least 200 mm. In the tests with the car axles they are not to be turned, but the blows are to be applied in the same direction.

After each blow the amount of bending is to be measured, and the fall height of the tup regulated according to the bending, which has taken place. The last blow may be regulated in intensity according to the amount of bending to be accomplished.

The bending of the axles is to be measured at the upper surface of the axle and is to be computed in terms of the original span.

A semicircular rod device, with perpendicularly attached movable measuring strip at the center, with millimeter scale is to be used in measuring the bending of the axles.

The temperature of the axle is to be determined during the test and noted.

(*c*) *Drop Test With Wheel Tires.*—The tires, placed perpendicularly under the hammer, must be able to bend under the blows of the tup, which fall on the center of the tread, in the manner described in the following without showing any signs of failure. The impact work of blow shall be 3000 kgm and shall be increased each time by 500 kgm if the flattening is less in amount than 10 mm for each blow. After each blow the diminution of the perpendicular inside diameter is to be determined with calipers and the fall height of the tup regulated according to the amount of bending which has taken place. The last blow of the hammer may be taken of an intensity to correspond to the amount of bending to be accomplished. The temperature is to be noted.

Tender and Car Tires of Martin, Thomas, or Bessemer Steel.—The flattening of these tires shall be at least 12 per cent of the original inside diameter.

Locomotive Tires of Martin or Crucible Steel.—The flattening in this case may be calculated from the formula

$$E = \frac{D}{100} - \frac{d-65}{10}$$

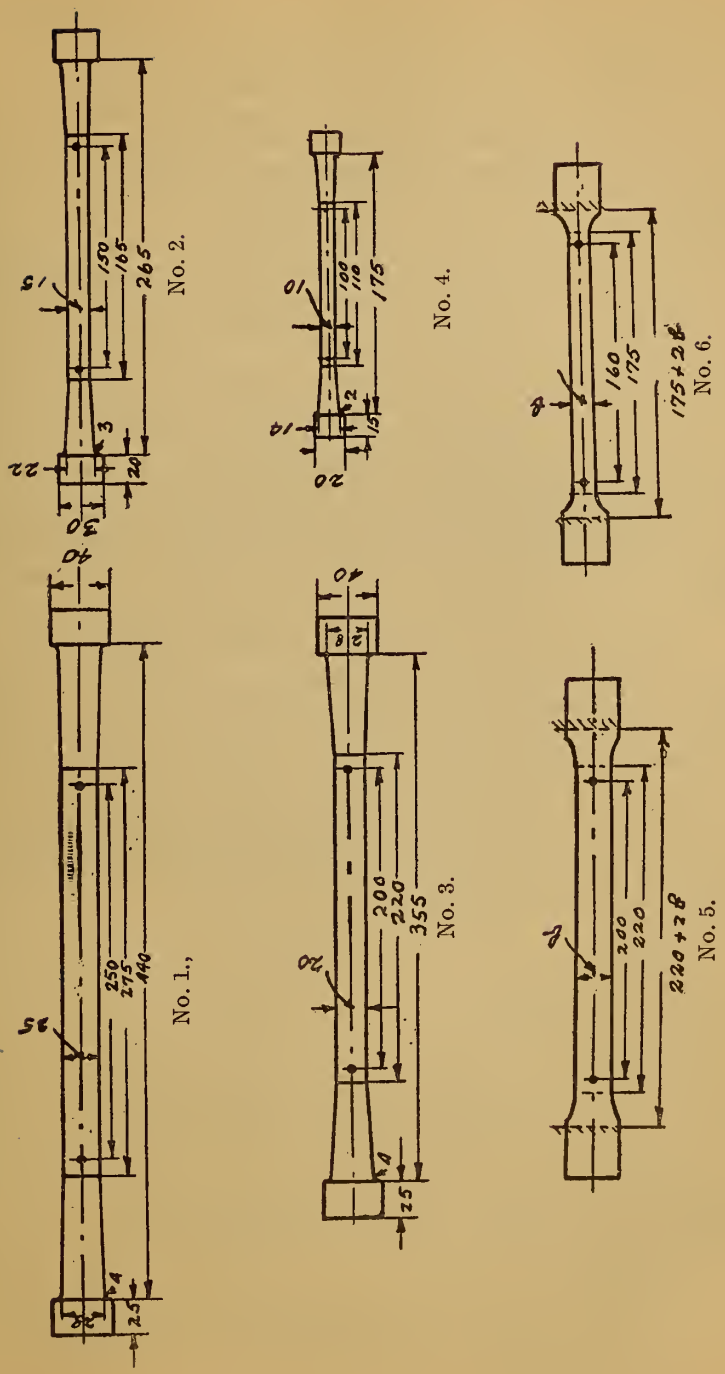
In this formula E is the flattening in per cent, D the tread circle diameter, and d the average tire thickness in the tread circle in millimeters.

(*d*) *Drop Tests With Wheel Centers.*—The wheel centers are to be laid with the rim on wooden supports in a horizontal position. A mandrel, consisting of four segment pieces, whose inside width is diminished by 1 mm in 20 mm is placed in the hub bore. A steel cylindrical wedge of square cross section, fitting exactly into the segment mandrel, is then forced under the drop hammer into this mandrel. For wheel centers with a hub bore of 145 mm this shall be done with six blows, for those of 130 mm bore, with five blows of 300, 400, 500, 600, 700, and 800 mkg, respectively. The mandrel and wedge are to be rubbed with oil before the test and wiped off. After this test the wheel centers must show neither in the hub, spokes, nor in the rim cracks or damage of any sort.

The test may, in the case of about one-third of the test wheel centers, be continued to destruction; if necessary failure is to be brought about by notching.

Uncommon phenomena in the deformation of the test pieces and in the type of fracture are to be investigated as fully as possible and noted.

Tensile and Elongation Tests.—The round test specimens shall have diameters of 10, 15, 20, and 25 mm, and shall correspond as much as possible to the dimensions of the sketches below. (See Nos. 1, 2, 3, and 4.) When possible, however, the diameter of 20 mm should be chosen. When round test specimens without heads are to be tested, and held in wedges, the length between the ends of the latter shall be as nearly as possible equal to the length between the shoulders of the normal test specimens of the same diameter.


No. 2.
No. 4.
No. 6.
No. 1.,
No. 3.
No. 5.

The flat specimens shall correspond in dimensions as much as possible to the drawings Nos. 5 and 6. Over the test length the cross section shall be at least 200 and when possible 300 mm^2, with a width of from 20 to 40 mm. The test length in the case of specimens of from 200 to 300 mm^2 in cross sectional area shall be 160 mm, that in the case of those of greater cross section, 200 mm.

In the case of axles, the test specimens are to be taken from the portions least bent in the impact test; in the case of tires, from the center of a cross section, which has been bent the least, and from a piece, which has been straightened as little as possible. The least bent portions are generally to be found at an angle of 40° to the vertical.

The round test specimens for axles, tires, and wheel centers shall have diameters of 20 mm, the flat test specimens, cross sectional areas of at least 300 mm^2, and both shall correspond as far as possible to the sketches 3 and 5. Only for the test specimens of cast steel and of cast soft steel may the elongation be measured over a test length of 100 mm.

When a test specimen, because of definitely recognizable fault of machining or local material flaw, or of faulty method of holding in the testing machine, gives an unsatisfactory result, the results are not to be considered as a criterion of the quality of the material with respect to tensile strength and elongation.

When the fracture occurs outside of the center third of the test length, the result for the tensile strength still holds, but not that for the elongation if the latter do not reach the prescribed amount. For the correct determination of the latter a new test specimen must be tested, in which fracture must occur in this center third of the test length.

CONSTRUCTION AND TRAFFIC RULES, GERMAN STATUTES, 1904*

Wheels.—29. Wheel Pressure.—The wheel pressure of trains not in motion may not in general be greater when loaded to full capacity than 7000 kg.

On track over which the superstructure and bridges are sufficiently heavy the pressure may be as great as 8000 kg.

31. Wheels.—(1) The wheels must be fastened securely on the axles.

(3) The tread circle must be at least 850 mm in diameter.

(4) The wheels must have flanges, except in the case that there are three or more wheels on the same frame, in which case the middle wheels need not have flanges.

(5) Measurements of Wheels:

	Mm
(*a*) Width of tires:	
Minimum	130
Maximum	150
(*b*) Thickness of tire, minimum	25
(*c*) Height of flange over tread:	
Minimum	25
Maximum	36
(*d*) Thickness of flange, measured 10 mm beyond the tread, minimum	20
(*e*) Play of wheels on the rails (side):	
Minimum	10
Maximum	25

Axles.—The greatest allowable stresses by static loading shall be:

	Kg/cm^2
(*a*) For axles of steel (Flusstahl):	
For freight cars—	
In journal	700
In the wheel seat	560
For passenger, baggage, and mail cars, and tenders—	
In the journal	560
In the wheel seat	450

(*b*) For axles of wrought iron:

For freight cars—	
In the journal	590
In the wheel seat	470
For passenger, baggage, and mail cars, and tenders—	
In the journal	470
In the wheel seat	380

GERMAN RAILWAY CAR ASSOCIATION

SPECIAL REGULATIONS CONCERNING THE CONSTRUCTION AND FURNISHING OF FREIGHT CAR WHEEL SETS (1910)

Materials.—(1) The regulations furnished as a supplement are authoritative for the quality and testing of materials.

(2) Axles and tires are to be made of steel (Flusstahl), spring rings of soft steel (Flusseisen), the body of the wheel (wheel center and plate center) of soft steel, wrought iron, or cast soft steel.

(3) The method of manufacture of the steel is, in so far as it is not prescribed, left to the manufacturer; it must, however, be stated in the bid.

Construction.—(1) The axles must be forged from sound, homogeneous ingots under the hammer or press. It is allowable to roll the ingots or forged axles in order to give a smooth surface. If the axles are each forged from separate ingots, the average cross section must be at least four times as great as that of the rough forged axle; if, on the other hand, the axles are forged out of bloomed ingots, the average cross section of the ingot must be at least eight times as great as that of the rough forged axle.

(2) The axles must be turned down smooth over the whole surface; sharp shoulder edges are not allowed.

(3) The wheel seat must run without any shoulder (Ansatz) on the inner side of the wheel hub. The journals must be finished in the cylindrical part and in the throat ground and polished accurately to dimensions; work with the file is not allowed.

(4) The centers on the heads of the journals are to be made before the turning down of the axles. They may not be afterwards bored out.

(5) The wheel centers according to sketch must be welded together in the seat spokes, and rim to one piece and thoroughly cleaned. The wheel centers, according to sketch C9, are to be made by forging and rolling out of one piece (Ehrhardt's process), the wheel centers according to the same sketch (right), as one piece from soft cast steel (Krupp process). The spokes must be straight. Holes or other surface defects may not occur on any part of the wheel centers.

(6) The method of manufacture of the wheel plates must be given in the bids. Cast wheel plates are not accepted.

(7) The weight which may be placed in the periphery of a wheel, in order to bring the center of gravity in the axis of the seat bore, may not be more than 0.5 kg.

(8) The rim of the wheel body must be machined on the tire-supporting surfaces and on the faces, and must possess a uniform thickness.

(9) The hubs of the wheel body must be machined on both faces. The bore of the hub and the wheel seat must have a smooth surface; the boring of the hub must be made from the inside and the machining of the body of the axle from the journal.

(10) The tires must be manufactured from sound and homogeneous ingots by means of the hammer, the press, or by rolling. After rolling, they must be protected from too quick cooling. The inner surfaces of the tires and the grooves for the spring rings are to be machined, and sharp edges are to be avoided.

(11) The spring rings must be long enough that the two ends of the ring after insertion be not more than 1 mm apart.

Assembling.—(1) The two wheel bodies pressed on to any one axle must be of the same construction. The wheel centers must be so placed on the axles that the spokes of the wheels coincide when looking in the direction of the axle. In the case of plate wheels the holes for the grippers must also so coincide.

(2) The difference in weight between the two wheels of the same set may not be greater than 2 kg. The extra weights on the periphery of the wheels of the same set shall be as nearly equal as possible and shall both be in the same plane containing the axis of the axle and on opposite sides.

(3) The wheel bodies shall be pressed onto the axles in such a way that the pressure be transmitted through a sleeve inclosing the journal onto the inner collar of the journal. The pressure shall begin at the latest after a distance of 20 mm and shall increase until the wheel is in position. The final pressure shall be between 60 000 and 90 000 kg.

(4) The wheel presses are to be provided with pressure gauges, which give a diagram of the course of the pressing of the wheel on the axle. The scale of this diagram shall be such that 100 atmospheres of pressure give 40 mm, and that the rate of unrolling of the record strip is at least 20 mm per minute.

(5) The tires are to be shrunk on with a shrinkage of 1 mm per meter inside diameter.

(6) The tires are joined to the wheel bodies by means of spring rings. The tires must be carefully dressed (angerichtet) over the whole periphery after the setting in of the spring rings, but must not show any tool marks after such treatment.

(7) The running and side faces are not to be machined until the tires are fastened on the wheel bodies. Both wheels must have accurately the same tread diameter (Laufkreisdurchmesser). The tread planes must be at the same distance from the center of the journals. The finished wheel sets must be accurately round.

Flaws of Manufacture.—It is not permitted to cover up flaws in the materials, such as welding joints, blowholes, etc., by cementing (welding) or calking.

Marking.—(1) The finished wheel sets shall be stamped in the following way on both ends of the axle (drawings are shown indicating the positions of the various marks, which are here omitted):

In letters 8 mm high, name of the firm furnishing the material for the axles with the number of the heat (year, heat, and ingot number), as well as the name of the material, and name of the firm providing the wheel set, with day and year of the delivery of the finished set.

In letters 15 mm high, shortened characterization of the type of wheel set (pair) and year in which the type originated, the two together giving the type of wheel; name of the owner; and wheel pair number.

(2) The tires are to be provided according to sketch on the outer ring surface 15 mm from the inner edge with the manufacturer's number, the mark of the contractor, the year of the delivery, the year and piece number, as well as the shortened characterization of the material. The abbreviated characterization of the material must be made according to the regulation above. In the case of tires which are submitted in the unfinished condition for delivery or sampling, a round impression of 2 mm diameter must be made for the acceptance stamp back of the mark characterizing the material. The digits of the heat number and the piece number must be 8 mm high; those of the other numbers, as well as the acceptance, must be about 5 mm deep, or at least must be so hammered in that they remain easily visible after the machining.

(3) The wheel bodies shall have on the outer surface of the hub in letters and figures 3 mm deep the mark of the delivering firm, the year of delivery, and the name of the owner in letters 15 mm high. The pressures in kilograms used in pressing the wheels on the axle shall be marked in letters 15 mm high, the weights and the

excess weights of the wheel bodies in kilograms in letters 8 mm high, the forcing pressure and wheel weight at a distance of about 10 cm from each other on the side toward the center of the axle, the balancing weight in the direction of its position on the side of the wheel toward the journal.

(4) The exact position of the balancing weight is to be indicated on both side surfaces and the inner surface of the wheel flange by a mark in white paint.

Supervision of the Manufacture and Inspection.—The regulations of the individual association administrations hold for the supervision of the manufacture and inspection of the wheel sets.

Painting and Packing.—The axle journals must be coated with a water-tight and acid-free paint, wrapped in oiled oakum, supported with wooden strips lying on the oiled wrapping, and held together with band iron, or at least in an equally efficient manner protected from damage. The other parts of the wheel set, with the exception of the tread circles of the wheel tires, are to be painted with colorless linseed oil varnish.

The wheel pair must be carefully packed and protected against any motion in order that they may not damage each other.

Guarantee.—The guarantee begins with the day of the final acceptance of the finished wheel set and lasts during a period of three years, and extends to all damage to the sets which occurs because of faults or flaws in the materials or mode of manufacture. The guarantee will be claimed by the owner of the wheel sets in accordance with the latter's regulations in regard to this matter.

ASSOCIATION OF GERMAN RAILWAY ADMINISTRATIONS*

TECHNICAL AGREEMENTS (VEREINBARUNGEN) CONCERNING THE CONSTRUCTION AND TRAFFIC ARRANGEMENTS FOR THE MAIN AND SPUR RAILWAYS (1909)[17]

A. Construction and Upkeep of Track.—(4) The rails shall be in general 9 m long. Greater lengths are recommended, up to 20 m.

(5) FORM OF THE RAILS.—The rail head shall be at least 57 mm wide, the running surface, straight or curved, with a radius of at least 200 mm. *New lots of rails must have a running edge curved with a radius of 14 mm.*

In the case of crosstie track with wide base rails a height of rail of 125 mm and width of base of at least 100 mm are recommended.

(6) CARRYING CAPACITY OF THE RAILS.—*The rails of lines carrying locomotives must be able to support at the greatest velocity wheel pressures which measure 7000 kg statically measured, and from the 1st of January, 1920, at the latest, on pressures of 7500 kg.*

In case of new track construction or of strengthening old track, provision must be made for wheel pressures of 8000 kg.

(7) It is recommended to give rails an inward slope of 1:20.

B. Construction and Upkeep of Rolling Stock.—(64) *The wheel pressure of rolling stock which is likely to be used on other railroads may not exceed in general 7000 kg.*

(65) WHEELS.—*The wheels on braked axles must be provided with shrunk-on tires, the wheel centers or plates of such wheels must be made of wrought iron, steel, or soft steel.* The use of cast iron for the hubs or for whole wheel plates is, in exceptional cases, allowed. *Steel-plate wheels, in which the hub plate and tire are cast in one piece, may only be used for unbraked axles. Chilled cast-iron wheels may be used only for freight cars (unbraked) in which the velocity does not exceed 50 km per hour.*

(66) The diameter of tender and car wheels shall at the tread circle be at least 840 mm. The tread circle is that circle made by the intersection of a plane perpendicular to the axle and at a distance of 750 mm from the center of it with the running surface of the tire or wheel.

(68) *The width of the tires may not be less than 130 mm and not greater than 150 mm.*

[17] Specifications in italics are obligatory, and those in ordinary type are only recommended.

Such tire-fastening devices are to be used that broken tires can not become loosened or come off in pieces from the wheel.

Sharp edges are to be avoided in tires.

The smallest allowable thickness of tires measured in the tread circle is set for all rolling stock at 25 mm. At the last machine cut the thickness shall not be reduced below 30 mm.

It is recommended to leave a shoulder on the outside faces of the tires in order that the thickness of the tires can be measured in the way mentioned above.

Wheel tires whose cross section is weakened by a groove under the throat of the flange must have a thickness of at least 20 mm.

The running surfaces of the wheels must slope outward from the flange toward the center.

(69) FLANGES.—*The wheels must be provided with flanges, except in the case of middle wheels of a frame.*

The height of the flange may not be less than 25 mm nor greater than 36 mm above the tread circle. When the flanges of a pair of wheels are unequally worn, the thickness of the most worn flange must be at least 20 mm at a distance of 10 mm above the tread circle.

(70) SIDE PLAY OF THE FLANGES.—*On a track of width 1435 mm the side play of the wheels must be more than 10 mm and less than 25 mm.*

(72) CAR AND TENDER AXLES.—*Freight car axles of steel must be heavy enough in the journal and in the wheel seat that under the heaviest static load the bending stress in the former is not greater than 700 kg, nor that in the latter greater than 560 kg per square centimeter.*

For axles of wrought iron the stresses shall not be greater than 590 kg in the journal and 470 kg in the wheel seat.

The axles of passenger, baggage, and mail cars and tenders shall not be stressed more than 560 kg and 450 kg when of steel, and not more than 470 kg and 380 kg when of wrought iron in the journal or wheel seat, respectively. Car and tender axles may not have sharp shoulders at or in the wheel seat, and they are to be avoided in general.

PRUSSIAN-HESSIAN STATE RAILWAY ADMINISTRATIONS*

SPECIAL REGULATIONS FOR THE SUPPLYING OF LOCOMOTIVES AND TENDERS (1913)

6. WHEEL PAIRS.—This is the same as special specifications for wheel pairs for freight cars of the State Railway Car Union 1910 with the exception of the following paragraphs:

(6) The wheel bodies of locomotives shall be made of soft cast steel, those of tenders of the same of wrought iron or of soft steel.

Rolled wheel bodies may be furnished for the tenders of freight locomotives.

(7) The position of the center of gravity of the wheels must be determined, and a greater weight than 0.5 kg may not be used at the periphery of the wheel to correct any eccentricity.

(10) The edges of the hub bore shall be rounded.

(16) Only wheels of the same kind may be pressed on the same axles, and the difference of weight between them may not be more than 2 kg.

AUSTRIA

STATE RAILWAYS

SPECIAL SPECIFICATIONS FOR RAILWAY RAILS (VIGNOLE AND CHAIR RAILS) (1909)

(Articles 1 and 2, dealing with the amount of the contract and the bond to be given, are here omitted.)

3. Kind and Properties of the Material.—The rails shall be made of steel.

The contractor must state in the bids what method of manufacture he will use, and this method will be stated in the contract.

The material of the finished rails must satisfy, in respect to its toughness and strength, the specifications of article 5.

The fracture must be fine and uniform and must not show fissures or blowholes.

4. Manufacture and Quality.—(1) The rails must be rolled exactly according to the normal drawings furnished with the contract and signed by the contractor, and according to the official templet furnished the contractor by the state railway authorities and provided with the official seal, which in turn corresponds to the normal drawing.

(2) The rails must be perfectly straight, may not be warped or contain cracks, seams, or other flaws. Such flaws must not be covered up by hammering or cementing (welding). After rolling the rails may not be again heated.

(3) The rails must show in every cross section the normal profile, and variations in the form of the tie-plate seat and in the height of the latter with respect to the running surface are not allowed; differences in the height and width of head of ± 0.5 mm and of the width of base of ± 1 mm are allowed.

(4) The ends must be perfectly even and smooth and perpendicular to the rail axis, with the tie-plate holes bored according to diagram.

(5) The lengths in which the rails are to be delivered will be indicated to the contractor after drawing up the contract; tolerance of ± 2 mm will be allowed in the length of rail of 9 m and below, of ± 3 mm in all lengths over this.

(6) The length predominating in the contract or order is to be looked upon as the normal length.

(7) In order to make the manufacture easier, rails which have come from the rolls in a damaged condition at the ends may be shortened by cutting off these ends.

(8) The number of these shortened rails allowed will be determined by the state railway officials; in cutting down the rails, lengths must be adhered to, which will be made known to the contractor.

(9) All rails of abnormal length are to be marked according to special direction with oil paint on the web.

(10) The rails, after having been finished in the mills, must be protected from nonuniform and too rapid cooling.

(11) Such a process must be used that the rails after cooling may be as straight as possible. A small amount of cold straightening may be done in the cold straightening press by means of repeated and moderate application of the load, which at each application corrects only a small part of the curvature, and which may be applied only to the web in the case of side curvature. No marks should be left on the rail by this process.

(12) The rails may be cut to length only with the circular saw or the milling machine. Tie-plate holes must be bored and notches may not be punched or chiseled out.

(13) The burrs from boring or milling must be removed.

(14) Each rail must have on it the trade-mark of the firm, the year of the delivery, and the characterization of the kind of steel used. These marks shall be on one side of the rail on the web in raised letters. Each rail must also have on it the heat number, with the exception of those shortened rails made from normal rails.

(15) All rails which in one or another characteristic do not correspond to these requirements or show that improper repair work has been done shall be rejected.

(16) The date of the beginning of the rolling of the rails ordered is to be announced in writing eight days before.

5. Tests of Quality.—(1) The rails shall be tested in the factory by the official of tests aided by the contractor.

(2) To the inspector shall be given a list of the heats to be used in the production of rails, together with the number of rails to be obtained from each.

(3) The testing and acceptance will always be done upon notice from the contractor, as soon as all rails, when less than 1000 are ordered, or when more are ordered, at least 1000 rails are ready for test.

(4) The rails when finished shall be divided into groups of about 200 pieces, and one rail from each of these groups shall be chosen for the purpose of the test. A group of rails remaining, and greater in number than 100, as well as single lots of rails over 100 and under 200, are to be considered as a full group, whereas remainders of less than 100, or single lots of less than 100 rails, are not to be considered in the testing.

From each of the rails to be tested shall be cut with the saw two pieces about 1.3 m long, one piece about 0.45 m long, and, in addition, in the case of rails which weigh more than 30 kg to the meter, one piece about 0.15 m long. These are, respectively, for the transverse bending test, the impact test, the tensile test, and the last for the ball-hardness test carried out for the purpose of obtaining information. It is permitted the inspector, however, to take these pieces, during the rolling, from the still red-hot rolled bars—but without hindering the work of rolling—with the saw.

(5) Rails of one heat are to be put in the same group.

(6) If the rail chosen fails to meet the requirements, a second and third may be taken from the same heat and tested in the same way. If either of these latter rails fails to meet the test, the whole heat may be rejected. The other rails of this group shall be considered as a new group and resubjected to test in the usual way.

(7) If the cases in which rails in consequence of faulty material must be rejected repeatedly occur, the state railway administration is justified in obtaining those rails, which have not yet been offered for acceptance elsewhere at the expense of the contractor.

(8) The tests are to be carried out in the following manner:

THE TRANSVERSE BENDING TEST.—(9) This test is made by supporting a piece of the rail about 1.3 m long on supports 1 m apart and loading it at the center for five minutes with a nonimpact load, and using if possible an automatic recording device to obtain the stress-strain diagram, whereby after removal of the load no permanent deformation shall have been suffered.

(10) The load in kilograms shall be calculated from the formula

$$P=120\frac{J}{e}$$

where J is the moment of inertia in centimeters^4 of the section with respect to the center of inertia, and e is the distance of the center of inertia from the most heavily stressed fiber in centimeters. This load must act on the head of the rail and only be gradually reached. The test is to be repeated and the load increased to a value from 25 to 30 per cent higher than that at which the material yields. The deformation is to be measured and referred to a fiber length of 1 m.

THE IMPACT TEST.—(11) The piece of rail to be tested is placed upon supports 1 m apart with the head up and in such a position that striking face of the tup of weight of 500 kg shall strike the rail at the center of the span and at right angles to the axis of the rail.

(12) The fall hammer shall be so constructed that the line of the center of inertia of the hammer coincides with the center line of the perpendicular guides and that these guides do not hinder the free fall of the hammer.

(13) The striking face of the hammer tup shall be rounded with a radius of at least 150 mm.

(14) The supports must be fastened to an iron base of at least 10 000 kg weight embedded in masonry, and arrangement is to be made to prevent the tipping over of the rails, as well as the springing out of the rails under the blow, without interfering, however, with their free position.

(15) The tests must be carried out at a temperature of from 5° to 30° C.

(16) The test specimen must withstand one blow of impact work

$$A = 100 \frac{J}{e^2}$$

in kilogram-meters, and further blows of 0.4 of this value until a bending at the center of 100 mm for rails of height up to 129 mm and of 90 mm for rails of greater height has been reached, without fissuring or showing other signs of failure.

(17) The last blow may be regulated according to the bending to be accomplished.

(18) The bending is to be measured on the running surface of the rail and calculated to a fiber length of 1 m.

(19) With one-third of the test pieces the test is to be carried to destruction and the amount of bending is to be measured; if necessary, fracture shall be brought about by notching.

(20) Unusual phenomena in the mode of deformation of the test piece are to be investigated and noted.

THE TENSILE TEST.—(21) The tensile-test specimens may be cut out of the rails cold, only, and no such piece of rail or test specimen shall be subjected to any heat or other treatment before test, except that necessary to the taking of the specimen.

(22) A test specimen shall be cut from the head of the rail and shall have the form shown in the sketch (test length 24 cm and diameter 25 mm).

(23) The tensile strength must be at least 65 kg per square millimeter. Further, the elongation over 200 mm and the reduction of area must be determined.

(24) *The Ball-Hardness Test.*—For this test, which is carried out only in the case of rails with a weight of more than 30 kg per meter for the purpose of obtaining information, the 150 mm rail piece is used, and the penetration and diameter of depression of a steel ball of diameter 19 mm at a pressure of 50 000 kg and 10 000 kg, respectively, are to be determined.

(25) *The Chemical Analyses.*—The official of tests is to have access to the results of the chemical analyses made during the manufacture of the rails, and in particular to those of the heats of which test specimens are submitted for the mechanical tests. He is also entitled to take smaller test pieces (pieces of rail, etc.) from the plant for his own information.

6. Tentative Acceptance.—(1) The results of all of the tests carried out are to be drawn up in manuscript, and this is to be signed by the inspector of the State Railway Administration and the contractor or his agent.

(2) Each group of rails in the case of which the tests have been satisfactory must still be inspected, piece by piece, by the inspector in respect to its outer appearance, such as for form, position, and diameter of the bolt holes, for the length, etc., and then the determination of the real weight will be made.

(3) The inspector (for acceptance) of the State Railway Administration decides alone the question of the acceptability of the rails.

(4) The rails which are found to fulfill the specifications will be marked on both ends with a stamp and are then tentatively accepted.

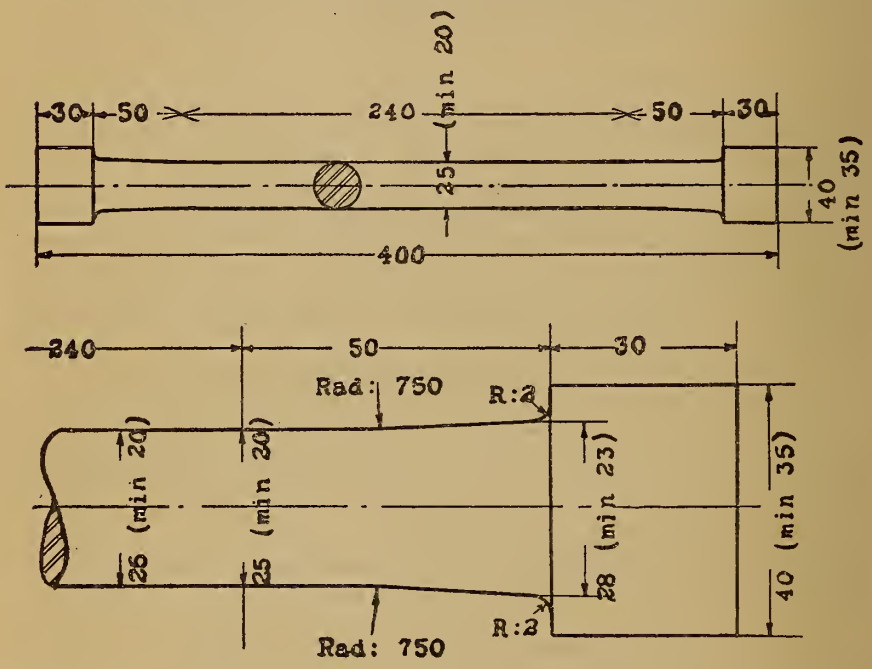
(5) In corroboration of this, the contractor receives from the inspector of the State Railway Administration a statement concerning the accepted and stamped rails, which gives their number, length, and weight.

(6) The stamped rails, if not immediately shipped, must be stored regularly in piles and protected as much as possible from rusting.

(7) Rejected rails are to be so marked by means of a crossed acceptance stamp.

(8) The contractor must see to it that of the whole order the proportion of number of rails of the different lengths, even in the part lots for delivery, shall be adhered to.

7. Normal Weight.—(1) The normal weight of any definite type of rail is that



weight which can be calculated for a length of 1 m on the basis of the known normal area of cross section and a specific gravity of the rail steel of 7.85 kg per cubic decimeter.

(2) For the determination of the actual weight, a determination, by means of a carefully tested scale or balance, shall be made under the direction of the inspector of the weight of 5 per cent of each accepted lot, and the weight of the whole lot calculated from this result.

(3) Excess weight is allowed up to 3 per cent; underweight, up to to 2 per cent of normal weight.

(4) The actual weight will be paid for, with the reservation that overweight over 1 per cent will not be paid for.

8. (This article deals with the shipping of the rails and is here omitted.)

9. Final Acceptance.—(1) The final acceptance takes place at the place of destination after verification of the stamp of the inspector at the rolling mill, verification of the marking of rails of abnormal length, and further, after investigation of the superficial appearance of the rails and determination of the number of the same.

(2) Unstamped, as well as stamped, but damaged or bent, rails will be rejected, which are to be replaced by rails of the same sort without flaws at his own cost by the contractor and removed.

(Further clauses follow, of no technical importance, relating to a possible further weighing of the rails.)

10. Guarantee and Claim for Replacement.—(1) The guarantee imposed upon the contractor (see the General Regulations Concerning the Bidding on and Furnishing of Material and Equipment, edition 1902) for the specified quality of the Vignole and chair rails begins with the acceptance and ends after five years, which in the case of rails which are intended for laying in old track is counted from July 1 of the year marked on the rail. In the case of rails intended for laying in new track the guarantee period is counted from a date three months before the day of the opening of the new line or division.

(2) Rails which are damaged after final acceptance in consequence of carelessness in transporting, or through accidents out of the ordinary, such as derailments, cave-ins, etc, or because of being run over by locomotives or ballast trains before the completion of the proper substructure, are to be replaced by the contractor only in case flaws or defects in the material or method of manufacture are discovered.

(3) On the other hand, the contractor must replace all rails during the guarantee period which in the course of ordinary service of any kind are damaged in consequence of defects in the material or arising in the mode in which the rails have been manufactured—as, for instance, broken rail, flowed head, or deformed rail—within two months after the claim has been sent to him by the State Railway Administration by repayment of the cost of the rails.

(Articles 11, 12, and 13 deal with the payment, penalties, etc., which are here omitted.)

SPECIFICATIONS FOR AXLES FOR LOCOMOTIVES, TENDERS, AND FREIGHT CARS (1909)

1. Material, Manufacture, and Quality.—The material for axles may be only basic Martin steel, or a steel known to the buyer to be the equal of this material; it must be tough and homogeneous and of equal hardness throughout; the method of manufacture is subject to the acceptance and approval of the party ordering the axles.

Two qualities are distinguished—basic Martin steel, mark A, of from 55 to 65 kg per square millimeter tensile strength and at least 16 per cent elongation; basic Martin steel, mark B, of from 45 to 55 kg per square millimeter tensile strength and at least 17 per cent elongation.

The phosphorus content may not be greater than 0.05 per cent. The axles shall be made by forging or pressing down ingots. Each axle is to be forged into a length longer than the finished axle is to be, and this extra length is such that it can be removed by chisel or hammer. The finished (forged) axles shall be suitably annealed and cooled out of contact with the air. The axles must be free from blowholes, pipes, fissures, and other flaws.

2. Dimensions and Weight.—The axles are to be furnished according to order as forged, rough machined, or machine finished. The dimensions indicated in the sketches included in the order or contract for the axle in either of the conditions mentioned are to be adhered to, and in no case may the dimensions be less than these. The weight given on the sketch may not be exceeded by more than 5 per cent for the forged or 3 per cent for the rough machined axles, and further overweight will not be paid for.

(Article 3 deals with the marking of the axles and is here omitted.)

The inspector must be furnished with a list of all axles which are to be submitted, which, arranged according to the order, contains the numbers of the heat or of the ingot of each axle. After acceptance the acceptance stamp of the railway administration is to be framed with a line of white paint in order that it may be easily visible.

4. Testing of the axles.—The "Regulations for the Testing of Materials for Rolling Stock" form a supplement to the following specifications:

(*a*) DROP TESTS WITH LOCOMOTIVE, TENDER, AND FREIGHT-CAR AXLES.—With respect to the testing of axles for locomotives, from the first lot of each heat one axle shall be chosen for the drop test. If the rest of the steel of this heat is used for the production of further lots of axles for the same order, then on one axle of each lot an extra length of 400 mm will be left from which a tensile specimen can be cut.

In the case of axles for tenders and freight-car wheels one axle from each heat will be chosen.

The axle to be tested is placed with the wheel seats on two rounded supports, which are fastened to the base of the drop-testing machine. The distance between these two supports shall be 1.5 m. This axle shall be subjected to blows of 3000 kgm impact work until the bending measured on any 1.5 m long fiber is equal to that calculated from the following formula:

$$E=\frac{1350}{DF}$$

where E is the bending in millimeters, D the diameter in meters of the axle at the center, and F the maximum tensile strength for the material type in question. The impact work of the last blow is to be so chosen that the bending prescribed is not much exceeded. Then the axle is turned through 180° and straightened out in the same way. The axle must not develop fissures or fracture during this deformation. The axle is then to be tested to destruction in order to judge of the structure, and for this purpose may be notched. The fracture must be uniform and fine and may contain no pipes or blowholes.

In order to carry out the foregoing test with locomotive axles it is permitted to machine the axle to the uniform diameter of the middle part.

(*b*) THE TENSILE TEST.—From each axle tested under the fall hammer two tensile test specimens shall be cut out cold of the wheel seat part, except in the case of locomotive axles. In the inspection and acceptance of locomotive axles, the heat of which has already been subjected to the drop test, the control tensile test specimens shall be taken from the extra length.

If one of the tensile specimens gives results under the required values, the average value of the two tests may be taken.

(*c*) FAILURE TO MEET THE TEST.—If of any one heat the first axle fails to meet the impact test, two more axles shall be chosen and subjected to the same test. If either one of these latter axles fails to meet the requirements of the specifications, the heat must be rejected.

If the results of the tensile test on an axle which has met the drop test are not satisfactory, the repetition of both tests with another axle of the same heat is allowed. The failure of either one of these tests allows of the rejection of the whole heat.

(*d*) The railway administration reserves the right to make other tests, such as chemical and etching tests, to assure itself of the quality of the material. The phosphorus content may not be greater than 0.05 per cent and heats whose chemical anaylsis is not satisfactory may be rejected.

SPECIFICATIONS FOR TIRES FOR LOCOMOTIVES, TENDERS, AND FREIGHT CARS (1910)

1. Material, Manufacture, and Quality.—Tires must be made of basic Martin steel or of material known to the consumer as of equal quality, and it must be of the best quality tough, homogeneous, and without flaws and of the proper hardness. The mode of manufacture is subject to the approval of the party ordering the tires. The phosphorus content must not be above 0.05 per cent.

There will be distinguished between the following qualities:

(*a*) Basic Martin steel, mark 1, of more than 75 kg per square millimeter tensile strength. The railway administration reserves the right to order such material with properties to be especially agreed upon.

(*b*) The same, mark 2, of 65–75 kg per square millimeter for locomotive and tender tires.

(*c*) The same, mark 3, with 55–65 kg per square millimeter for freight-car tires.

For the last two materials the sum of the numbers for the ultimate in tension and five times the elongation in per cent must be at least 130.

(A table of the ultimate strengths and the corresponding elongations is given, which is not here reproduced.)

Before their further manufacture, porous or other inhomogeneous parts of the tire ingots must be removed.

The rolled and finished tires are to be suitably annealed and left to cool out of contact with the air.

The finished tires may not contain fissures, pipe, splinters, slag (Schiefer), or other porous or defective spots. The tires must be rolled out smooth, equally heavy, accurately round, and not warped, and such that the increase of 1.5 mm in the diameter is sufficient to allow of shrinking on of the tire, and that with this increase the finished and correct profile and cross section of the tire may be attained in all sections.

2. Dimensions and Weight.—The tires are to be manufactured according to the indications given in the order, and must fully correspond to the dimensions of the sketch. In particular the tires may not possess a greater inner diameter than that prescribed; a smaller diameter by at the most 1.5 mm is allowed. The inner cylindrical surface of the tire must be accurately perpendicular to the plane side flange surface.

The weights of the different tires are given in the corresponding sketches. Excess weight of more than 5 per cent will not be paid for.

(Article 3 deals with the marking of the tires, and is here omitted.)

4. Testing.—The "Regulations for the Testing of Material for Rolling Stock" form, according to their applicability, a supplementary part of the following specifications.

To the inspector is to be given before the beginning of the inspection a list of the finished tires, ready for inspection, the list being arranged according to the order and the heats. The inspector will choose with the aid of this list and after inspecting the tires submitted, the tires, which will be tested.

(*a*) Drop Test.—For the drop test one tire from each heat will be chosen.

The tire is placed under the hammer on a support, which is correspondingly rounded; a similar piece is placed under the tup; the tire must flatten out under the blows of the hammer tup by an amount equal to $\frac{75\ D}{100\ F}$ per cent of the original inside diameter, in which D represents the original inside diameter and F the lower tensile strength limit of the material type under test. The impact work of each blow shall be 3000 kgm. This flattening must be accomplished without any evidences of fissuring, and the blows are to be continued until the deformation has reached the above value; the last blow is, however, to be chosen of such an intensity that the required deformation is not much exceeded.

If the calculated amount of bend has not been reached without fracture, it is allowed to take from the tested specimen a tensile test specimen and determine the actual tensile strength, and if with this value of F in the above equation the deformation was great enough, it may be considered that the impact test has been passed.

Each tire under impact test shall finally be notched and broken. The fracture must show a dense and homogeneous structure.

(*b*) THE TENSILE TEST.—From each of the test tires subjected to the impact test shall be taken from that part least affected by the test, a test piece, which shall be straightened with moderate heating. From this shall be taken two tensile test pieces, one from the flange and one from the tread and subjected to the tensile test. The values obtained must satisfy the requirements above set forth.

(*c*) If the first test tire does not pass the drop test, two more tires shall be selected from the same heat and subjected to the same test. If either of these latter tires do not in any particular meet the specifications, all of the tires from this same heat will be rejected. If one of the tensile specimens of a tire which has passed the drop test does not fulfill the requirements of the tensile test, a repetition of the test is allowed. A second tire of the same heat is subjected to both of the above tests, and if only one of the specimens of this second test does not pass the test, notwithstanding that the tire has passed the drop test, all of the tires of this heat shall be rejected.

(*d*) The railway administration has the right to have parts of the tested tires subjected to a chemical analysis. The phosphorus content may not be more than 0.05 per cent. Heats, the chemical analysis of which is not satisfactory, may be afterwards rejected. The railway administration reserves the right to have etching and other tests made for the purpose of obtaining further information.

5. Further Regulations.—The "Supplementary Regulations for the Furnishing of Material for Rolling Stock" form an integral part of the preceding regulations.

SPECIFICATIONS FOR FORGED OR ROLLED WHEEL PLATES (1909)

1. Material, Manufacture, and Quality.—Wheel plates shall be of basic Martin soft steel (Flusseisen), of the best quality or of a material which is recognized by the consumer as being of equal quality. The method of manufacture is subject to the approval of the party ordering the wheel plates.

The wheel plates are to be suitably annealed.

There may be no flaws of any sort on the wheel plates, such as porous spots, fissures, etc.

2. Dimensions and Weight.—The wheel plates are to be made according to the data and sketches furnished with the order, and may be delivered as forged, rough machined, or in the finished condition. The normal weights of the wheel plates are given in the sketches, and excess weight of more than 3 per cent will not be paid for; excess of more than 5 per cent will not be allowed.

3. Marking.—All wheel plates receive on the inner surface, perpendicular to the axis, the following marks, in letters 4 mm deep, made, however, with tools which are not sharp-cornered: (1) Trade-mark of the firm; (2) year of delivery; (3) half-year of delivery; (4) number of the heat; (5) current manufacture number. To the inspector is to be given before the beginning of the inspection a list of the wheel plates to be inspected.

4. Testing.—The special regulations for the testing of materials for rolling stock form, according to their applicability, a supplement of these paragraphs.

One wheel plate of every heat in the rough, but annealed condition must be subjected to the following tests. The tests consist of the drop test and the tensile test.

(*a*) THE DROP TEST.—The test wheel is laid horizontally in a normal fall-hammer apparatus in such a way that it is supported at the periphery at all points over a width of about 10 mm uniformly, and is then struck at the hub by the hammer, and a suitable striking piece must be laid under the tup.

The impact work shall amount at the first blow to 1000 kgm, and shall be increased at each blow by 500 kgm as long as it does not reach the value of 3500 kgm, above which it does not need to be increased. Further blows are to be carried out with this latter maximum value when necessary. The drop test is to be continued until a bending at the center of 50 mm is reached.

(*b*) THE TENSILE TEST.—From every test wheel so tested in impact a tensible test piece shall be prepared; this is done by straightening (with moderate heating) and cutting out cold. The tensile test shall show a tensile strength of at least 42 kg per square millimeter and at the greatest 50 kg per square millimeter and an elongation of at least 18 per cent.

(*c*) If the test wheel first chosen shall not meet either of the tests, two more wheels of the same heat shall be chosen and tested in the same way; if either of these latter wheels fail to meet the requirements, the wheels of the whole heat must be rejected.

5. Supplementary Regulations.—The "Supplementary Regulations for the Furnishing of Material for Rolling Stock" form a part of the preceding specifications.

SPECIFICATIONS FOR SOFT CAST STEEL PARTS (FLUSSEISENGUSS WAREN) (1909)

1. Material, Manufacture, and Quality.—The material shall be only Martin soft steel or material known to the buyer to be of equal and of the best tough quality. The mode of manufacture is subject to the approval of the party ordering the articles.

The tensile strength of this material shall be at least 42 kg per square millimeter and not more than 50 kg per square millimeter with an elongation of 18 to 12 per cent, respectivcly, values between these to be linearly interpolated.

The phosphorus content may not be greater than 0.05 per cent.

The castings must be cast with coupons (Anguss) for test and analysis. The castings are to be annealed until the temperature stresses are removed. All castings must be without flaws, such as blowholes, fissures, etc., and must have a smooth surface. The coupons on wheel centers are to be left on until acceptance.

2. Dimensions and Weight.—The castings are to be made according to the data and the drawings furnished with the order. Locomotive and tender wheel centers shall be delivered either rough cast, rough machined (vorgeschroppt) or finished.

The specified weights must be adhered to as much as possible; excess weight of more than 3 per cent will not be paid for, and excess weight of more than 5 per cent is not permitted.

3. Marking.—(This article is omitted.)

4. Testing of Wheel Centers.—The "Regulations for the Testing of Materials for Rolling Stock" form, according to their applicability, a supplementary part of the following specifications:

(*a*) THE IMPACT TEST.—Each wheel shall be either as cast or as roughed, subjected to the drop test. In this test the wheel is lifted perpendicularly and allowed to fall on the rim such a distance that the impact work done amounts to 300 to 500 kgm.

The base of the fall hammer must have a weight of at least 4000 kg and at the point where the wheel falls a rail must be fastened to the base.

Each wheel center is to be tested twice in this way, the second time after being turned through a right angle.

In the case of wheel centers under 100 kg in weight the specifications are to be correspondingly changed.

(*b*) THE TENSILE TEST.—From two wheels of each heat, tensile test specimens shall be taken from the coupon (Anguss).

(*c*) A specimen for chemical analysis is to be taken from the cast-on piece of one wheel from each heat, and the results must satisfy the "Special Conditions For Testing Rolling Stock Materials."

(*d*) The official of tests is empowered to break the cast-on piece of each wheel center in order to gain an idea of the structure of the metal.

(*e*) FAILURE TO MEET THE TEST.—Wheels which fail to meet the requirements of the impact test, and fissure or break during the test shall not be accepted.

If one of the two tensile test specimens does not fulfill the specifications, two other specimens of the same heat are to be chosen and tested in the same way, but if either of these latter two does not meet the test satisfactorily, the whole heat shall be rejected.

If the chemical analysis is not found satisfactory, all wheel centers of that heat may afterwards be rejected.

(*b*) (This article deals with the testing of castings other than wheel centers.)

5. Supplementary Regulations.—The "Supplementary Regulations for the Furnishing of Material for Rolling Stock" form a supplementary part of the preceding specifications.

AUSTRIAN SPECIFICATION FOR CHILLED CAR WHEELS, PER CAR STANDARDS SHEET 18 (1910)*

For car wheel type $\frac{N}{07}$ the chill must penetrate from 12 to 20 mm. The treads must be ground perfectly round; variations of more than 1 mm are not permissible. The mounting pressure for chilled car wheels shall be at least 40 000 kg.

SPECIFICATIONS FOR CAR WHEEL PAIRS*

1. The two wheels of a pair must have accurately the same diameter, and excess of more than 5 per cent over the specified weight is not allowed.

2. Material, Manufacture, Quality, Marking, and Painting.—For regulations concerning the material and manufacture of wheel bodies, plates, centers, tires, and chilled car wheels, see the special specifications.

The wheel bodies are to be machined at the periphery and hub in the way shown in the sketches, and soft steel wheels for normal gauge track shall be pressed on with a pressure of at least 50 000 kg; for narrow gauge, with a pressure of at least 35 000 kg. Chilled cast wheels for normal gauge are to be forced on the axles with a pressure of at least 30 000 kg.

The tires are to be machined as in sketch and are to be drawn on to the wheel with a shrinkage of 1:1000.

The running surface of the chilled cast-iron wheels must be ground perfectly round.

After the tires are drawn onto the wheels they are to be machined as shown in the sketch.

Each wheel body must be balanced—that is, the center of gravity of the wheel must be located—and if it lies out of the center, a weight must be placed at the periphery to counterbalance it. Such a weight may not be more than 0.5 kg. Two wheels differing by more than 2 kg in weight may not be used on the same axle.

The wheels must receive the marks as shown in the sketch, trade-mark, name of owner, etc.

GENERAL REGULATIONS FOR THE FURNISHING OF MATERIALS AND EQUIPMENT FOR THE STATE RAILWAY ADMINISTRATION.*

11. Quality of the Materials and Inspection of the Manufacture—TESTS OF QUALITY.—(2) The railway administration reserves to itself the right to inspect, through its agents, the manufacture and preparation of articles furnished at the place of manufacture, to make tests of the quality of the articles or material, to have samples made and tested, and to inform itself at any time of the progress and quality of the work being done on articles to be furnished. The agents must therefore have at all times, during the manufacture of articles to be furnished, full access to that part of the plant engaged in this work, and must have full opportunity to inspect and inform himself concerning the manufacture of these articles. Material and apparatus must be furnished him for the purpose of making tests or measurements of any kind required or suggested in the specifications. The responsibility of the contractor for the quality of his product is not affected, however, in any way by this inspection.

HOLLAND

THE NORTH BRABANT RAILWAY [18]

Rails.—The rails are calculated for a wheel pressure of 7000 kg and have a weight of 33.7 kg.

The specifications for the Prussian State Railways hold for this latter material.

General.—The table below gives the physical properties of the material specified for axles, tires, and wheels.

Article	Variety of steel	Ultimate strength in tension	Elongation	Reduction of area
Carriages and cars:		Kg/mm²	Per cent	Per cent
Axles	Siemens-Martin steel	60–68	15–20	25
Tires	do	60–68	15–20	25
Wheel centers	(Vloeiyzer) soft steel	40–50	.....	.....
Spoked wheels	do	37–44	20	.....
Locomotives and tenders:				
Crank axles	Nickel steel	60–68	15–20	25
Other axles and tires	Crucible steel	60–68	15–20	25
Tires	Siemens-Martin steel	60–68	15–20	25
Tender wheels	Cast steel	38–45	20	.....

Axles—Tests.—One axle of each heat is submitted to the drop test. It is supported with a span of 1.50 m and is struck eight blows of 3000 kgm impact work for carriages and cars, of 5600 kgm for locomotives, and of 4200 kgm for tenders. The axle is turned 180° after each blow and must not break during this test.

Tires—Drop Tests—1. For Carriages and Freight Cars.—From each heat shall be taken one tire and submitted to a number of blows of 3000 kgm impact work. If the bending (flattening) is less than 10 mm, the blow must be increased by 500 kgm. The tire must be flattened by 12 per cent and not break.

2. For Locomotives and Tenders.—From each heat shall be taken one tire and tested in impact with blows of 3000 kgm. The flattening must be at least

$$E \text{ per cent} = \frac{D}{100} - \frac{d-65}{10}$$

where D is the diameter and d the thickness of tire. The flattening must be at least 12 per cent and on no tire less than 10 mm. In the latter case the impact work is increased by 500 kgm. The tire must not break by this test.

NETHERLANDS CENTRAL RAILWAY COMPANY [19]

General—1. Disk and spoke wheel centers for freight cars; forged disk wheel centers, passenger cars; forged spoke wheels, locomotives and tenders; cast spoke wheels.

2. Material and Physical Properties.—Requirements are the same as for North Brabant Railways.

3. Testing.—(See specifications for North Brabant Railways.)

[18] These specifications were received by letter of 1914 from this railway company.

[19] These specifications by letter from the Ministry of Railways, 1913.

STATE RAILWAY [20]

SPECIAL REGULATIONS FOR TESTING VARIOUS MATERIALS AND ARTICLES (No. 23, 1907)

Crank Axles for Locomotives.—MANUFACTURE.—The crank axles must each be manufactured out of one entire steel ingot of a dense and homogeneous structure, without welding, by forging or under the press.

The cranks must be forged from the full ingot, either directly bent into the proper position of the respective parts to each other, or forged straight and then bent, so that the proper parts come to a perpendicular position with respect to each other, as has been agreed on at the time of the contract. The material must be worked through and through, must be tough and sound, free from porousness, cracks, scale, and other faults. The fracture must exhibit a fine and uniform grain.

After being rough machined, each crank axle must be annealed, and thereupon slowly cooled.

MACHINING.—The crank axles must be smooth and clean over the whole length and be machined according to the drawings.

At the place where the hubs of the wheels or the outer cranks must be pressed on, the diameter of the axle must be left greater by 6 mm than the finished dimension.

The crank and bearing seats and collars must be polished smooth as a mirror, and each perpendicular cross section must be definitely circular. It is prohibited to work these parts with a file.

The center holes in the axle ends must be bored so deep before machining that they remain accurately according to the drawing; later boring of the center holes is not permitted.

TESTING.—In order to judge of the quality of the material, at least two bending and at least two tensile test specimens shall be taken from each axle. All crank axles must for that purpose be forged so much longer that on one end a sufficient length may be left for the preparation of the test bars, which are to be taken both from the core and from the outer part of the axle.

The tensile test specimens consist of cylindrical bars of diameter of 20 mm extending over the test length of 200 mm and 10 mm farther. The fillet at the test head shall be machined smooth.

The results of the tensile test must satisfy the following conditions:

	Nickel steel.	Steel (Kroezen).	Special Siemens-Martin steel.
Elastic limit in kilograms per square millimeter, at least.	40	32	30
Tensile strength in kilogram per square millimeters, at least	60	55	55
Elongation in per cent, at least	18	20	20
Reduction of area in per cent, at least	40	45	50
Sum of elongation and tensile strength, at least	80	78	78

The bending test specimens shall have a square section 30×30 mm; and the sharp angles must be rounded with a radius of 1.5 mm. The specimens shall have a test length of 200 mm. They must be capable of bending cold through 180° (double), so that the ends touch each other without cracks or other faults.

If the test taken with one crank axle be not satisfactory or only partly so, the axle shall be rejected.

MARKING.—(Omitted.)

[20] These specifications were received by letter of 1913 from the Ministry of Railways.

GUARANTEE.—For each delivered crank axle the manufacturer shall guarantee 165 000 km, which the axle must run under the locomotive, without breaking, failing, or showing any other fault. The manufacturer is bound to furnish a new axle satisfying all of the conditions of the specifications for each old one, which may have been put out of service, because of any fault before it had run at least 165 000 km, without cost to the railway, and this must be done as quickly as possible after the receipt of the notice of the failure of the old axle, within 3 months at the very latest.

PACKING.—(Omitted.)

SPECIFICATIONS FOR MOUNTED WHEELS (1911)

(Contract form is omitted.)

General—Material.—The axles and tires shall be of the best quality of Siemens-Martin steel, the wheels and spring rings of the best quality wrought iron (Welijzer) or Siemens-Martin steel (Smeltijzer), as is more definitely described in the contract.

In the bids the kind of material and mode of its manufacture must be given.

Axles.—The axles shall be forged by hammer or press, each from one whole steel ingot of dense and homogeneous composition without joining or welding. They are then annealed and allowed to cool slowly. The center cross section of the ingot must be at least four times that of the rough axle.

The axles must be turned smooth over their whole length, and must be cleanly round. Sharp shoulders are not permitted. The finished axles must be sound and smooth, and must not show scale, porosity, rough places (scheurtjes, schilfers, ruwe plekken), or other flaws; sharp fillets in the diameter must be avoided.

The machining of the wheel seat before pressing the wheels onto the axle must be done from the nearest end. The parts of the wheel seat must be manufactured so as to be smooth and sound; roughness (draairingen) from machining must be avoided.

The journals, necks, and collars must be polished with mirrorlike finish; working them with the file is forbidden. The cross section of the journals perpendicular to the axis of the axle must be cleanly round all over. The axles must be well centered. The center holes must be bored before machining so deeply that they remain in the finished axle in the exact position given in the drawings. Subsequent boring of these center holes is forbidden.

(There is here omitted a paragraph dealing with the marking of the axles.)

TESTING—*Drop Test.*—One axle of each lot of 50 or less, at least one of each heat, shall be chosen for test. These axles, roughed or finished, are submitted to the drop test. Each axle is placed on firm saddlelike supports, 150 cm apart, fastened to an anvil of iron of at least 10 000 kg weight. The supports on which the axles rest are saddle-shaped, with a semicircular cross section of radius of 50 mm. The hammer tup must fall freely without friction; the blows are to be directed at the center of the axle. The impact work of each blow shall be 3000 kgm, and the axles must withstand four blows in the same direction, and as many more as are necessary to bend the axle by 20 cm (200 mm). In this process the axles must show no fissures and must not break.

During the test the axles must not be turned over, but must be bent in the same direction at each blow. After each blow the amount of bending is to be measured, and at the last blow the fall height is to be adjusted according to the amount of bending yet to be accomplished.

The bending must be measured on the upper edge of the axles, and each time with respect to the distance between the supports. In measuring the amount of bending, use may be made of an instrument having the form of a semicircular compass, with a movable slide at the center, calibrated in mm and perpendicular to the circular rod of the compass.

The drop test may be continued until the axle breaks; if necessary, the axle may be notched so that it may be broken. If the test of one axle is not satisfactory, or only partially so, then two other axles of the same heat may be offered to the inspector for test. If these, or only one of them, do not comply with all the requirements, then all of the axles of the same heat shall be irrevocably rejected. During the drop test the temperature of the axles shall be noted.

The Tensile Test.—From each axle tested under the fall hammer a piece is to be taken, from which, after the heat number has been taken from the inspector's stamp at least two test bars 200 mm long and 20 mm in diameter are to be taken from the center of the cross section. The tensile strength must be from 52 to 60 kg per square millimeter, the elastic limit at least 30 kg per square millimeter, the elongation over the test length of 200 mm at least 20 per cent, and the reduction of area at least 30 per cent of the original area.

If the tests with one of the two test bars taken from the same axle are not satisfactory, or only partly so, there shall be taken from the same axle, which must, however, first be provided with an inspection stamp, two more test bars of the same dimensions. If the test on both of these bars does not fulfill all conditions, all of the axles of the same heat will be irrevocably rejected.

Wheels.—The iron to be employed in the manufacture of wheels must be dense, easily forged, tough, neither cold nor hot short, free from slag, porosity, fins, cavities, and other faults (slakken, schilfers, bladders, laschnaden, kantscheuren). For welded wheels the material must be easily weldable.

The mode of manufacture of the wheels must be given in the bid. Cast plate wheels are not accepted.

In the case of forged or welded spoke wheels, the hub, the spokes, and the rim must be joined together into a whole piece and worked clean, sound, and smooth. No traces of burning may appear. The spokes of the wheels must be of uniform thickness and carefully adjusted. They have to be worked so that no unevenness may appear. At the place where the plates join with the hub or the rim the wheel must be machined smooth, as in the drawing.

The rim of the wheels must be cleanly smooth on its periphery, and on both sides must be machined according to the dimensions and have the same cross section over the whole periphery. Both end faces of the hub, the hub bore, and the cylindrical outside face must be machined.

The machining of the hub bore before the pressing of the wheels on the axles must be done from the inner face. The bore must be machined soundly and smooth.

Machining roughness (draairingen) must be avoided.

The inner diameter of the hub of the wheels must be so much smaller than the diameter of the axle at that part of the hub that the wheels may be pressed onto the axle by a gradually increasing pressure of at least 60 000 kg, and at most 90 000 kg.

(There is omitted a paragraph dealing with the marking of the wheels.)

Testing of the Wheels.—From the number of wheels offered for test in the case of spoke wheels, 2 per cent shall be taken, with a minimum of 1 wheel. In the case of plate wheels 1 wheel from each 50 wheels, or part of 50, of the number offered for test, but at least 1 wheel from each heat shall be chosen for test. At least 50 wheels are to be offered for test at one time, unless otherwise provided for.

Hub Bore Expanding Test.—The wheel to be tested is placed upon wooden supports, with one of the side faces of the rim being perfectly level. A four-segment mandrel, with a square opening in the center, is shoved into the bore. Into this opening a steel wedge of the form of a truncated regular square pyramid of a conicity of 1:20 must fit completely.

This wedge is to be driven in by 6 blows, whereby the product of the fall weight in kilograms and the fall height in meters shall be successively 300, 400, 500, 600, 700,

and 800. After this test the wheel must not show any cracks or other flaws. The wheel may then be broken.

Before being employed in this test, the wedge and the inner sides of the mandrel are to be oiled and then wiped dry.

If the wedge tests taken with one or more wheels are not satisfactory, then the testing official may take for test a double number of the spoke wheels first tested, which had not been satisfactory, or two plate wheels, respectively, of the same heat. If these do not fulfill all conditions, or if only one of them does, then all of the spoked wheels offered for test or all plate wheels of the same heat shall be irrevocably rejected.

TENSILE TEST.—From the wheels thus tested three test bars are to be prepared and tested, one from the hub, one from the spoke or plate, and one from the rim, after they have first been marked. The diameter of the cylindrical test bars shall be as nearly as possible 20 mm. In the case of test bars with a square cross section, this cross section is to be about 300 mm^2, and the test length, about 200 mm, or as near to that value as possible. The material of the wheels must satisfy the following conditions:

Material	Tensile strength, in kilograms per square millimeter, of the original cross section	Elongation, in per cent, of the 200 millimeter test length
Wrought iron for forged spoke wheels	At least 34	At least 12.
Siemens-Martin steel for forged spoke wheels	34 to 41	At least 25.
Siemens-Martin steel for plate wheels	40 to 50	At least 20.

If the tests with one or more test bars taken from the same wheel are not satisfactory, or only partly so, then from that lot from which the test bars were taken two others of the same dimensions may be prepared, after the stamp of the inspection has been provided. If the tests taken with both of these bars are not satisfactory in all respects, all of the spoked wheels offered for test or all of the plate wheels from the same heat shall be irrevocably rejected.

EQUILIBRATION.—For this purpose each wheel, after forcing upon the axle according to the requirements of the first part, in the factory of the contractor, is to be placed upon two steel-bar supports, smooth, horizontal, and of uniform width and height. The weight which has to be applied to the rim of the wheel in order that the center of gravity may be in the geometric axis may be not greater than 0.5 kg.

Tires.—Each tire must be manufactured from one entire steel ingot of a dense and homogeneous structure, without welding or joining, by means of hammers or presses and rolls. After the rolling out of the tires they must be appropriately protected against sudden cooling. The tires must not show any faults of rolling, fins, cavities (scheuren, bladders), or other faults. The manner of preparing the material, as well as the method of manufacture, of the tires must be explained to the inspector on request.

(There is here omitted a paragraph dealing with the marking of the tires.)

The inside upper face of the tire and the grooves for the fastening of the same onto the wheel center are to be machined smooth, according to the sketches and sharp fillets must be avoided. The inside diameter of the tire must be smaller than the outside diameter of the wheel by so much that the shrinkage measure may be 1 mm for each meter of inside diameter.

The material must be so tough that upon being shrunk onto the wheels the tires will not show any cracks, fracture, etc.

The heating of the tires before their cooling after being shrunk on must be done in such a manner that the tire will retain the same degree of hardness all over which it had before the heating.

This heating shall not cause the diameter to become more than 2 mm larger than that of the cold tire.

TESTING OF TIRES.—One tire of each 50 tires, or part of 50, of the number presented for inspection, but at least 1 tire from each heat is to be offered to the inspector for testing. Not less than 50 tires are to be offered for test at the same time, unless otherwise provided for.

The Drop Test.—The tires are to be subjected to drop tests, and for this purpose are to be placed under the hammer tup on a support, which is fastened on a foundation block of iron weighing at least 10 000 kg. On the upper part of the test tire, where the tup is to fall, there is to be placed a piece of at least 20 kg in weight, flat on the upper side and having approximately the profile of the tire on the lower side. The cover piece and support are to be curved with a radius of about 150 mm on that side which comes in contact with the tread surface. The tup must fall freely without friction. During the drop test the temperature of the tire is to be taken.

The product of the numbers giving the fall height in meters and the fall weight in kilograms must be 3000. The wheel tires receive at least four blows at the center of the tread surface, or so many more as may be necessary to produce a reduction of at least 12 per cent in the original inside diameter.

When the prescribed reduction of the diameter has been reached, the tires must not show any cracks or fracture, and must not be broken. After each blow the diminution of diameter is to be measured. The drop test may be continued until the tire is hammered flat or until it breaks. If necessary, the tire may be notched in order that it may be broken.

If the tests taken with one tire be not satisfactory, or only partly so, then two more tires of the same heat may be offered to the inspector for testing. If these, or one of them, do not comply with all conditions, all of the tires of the same heat shall be irrevocably rejected.

Tensile Test.—From each tire which has been tested in the drop test at least two tensile-test pieces are to be prepared from that part of the tire which has suffered the least (at the choice of the manufacturer), and as far as possible from the center of the cross section. These shall have a test length of 200 mm and a diameter of 20 mm.

The material for the preparation of these test bars must not be warmed or heated, unless it be unavoidable, and in that case not more than is strictly necessary for the obtaining (bending) of the specimen.

The tensile strength must be at least 55 kg per square millimeter, the elastic limit at least 32 kg per square millimeter, the elongation at least 18 per cent of the 200 mm test length, and the reduction of area at least 30 per cent of the original cross section.

If the tests taken with one or more test bars from the same tire are not satisfactory, or only partly so, two more test bars are to be prepared of the same dimensions from the same tire, which must be first provided with the testing stamp. If the tests made with both these bars do not fulfill all conditions, all of the tires of the same heat shall be irrevocably rejected.

Spring Rings.—(Omitted.)

Testing of Spring Rings.—(Omitted.)

Mounting of Wheels.—(Omitted.)

FAULTS.—It is forbidden to cover up faults in the material or in the method of manufacture in any way.

INSPECTION.—The contractor shall furnish all of the tools, apparatus, measuring instruments, and personnel necessary without cost, and must bear all of the cost of renewal of parts broken during the test.

The railway company has the right to manufacture the minor parts and to assemble the wheel in the shop of the manufacturer, through one or more persons, who direct the work. These persons must have at all times free access to the shops when the

axles, wheels, tires, and spring rings are being made and worked, or where the minor parts are being assembled. They are wholly free in the inspection of the pieces to be tested, and are authorized at any time to make a test which they consider necessary.

The equilibrating of the wheels, the shrinking of the tires onto the wheels, and the pressing of the wheels onto the axles take place in the presence or one or more persons designated by the railway company.

Deviations in dimensions are not permissible; all measuring must be controlled carefully by means of templets, compasses, etc.

REJECTION.—(Omitted.)

STAMPING AND PAINTING.—(Omitted.)

PACKING.—(Omitted.)

DISPATCH.—(Omitted.)

DELIVERY.—(Omitted.)

TRANSPORTATION.—(Omitted.)

PRICE AND CONDITION OF PAYMENT.—(Omitted.)

Guarantee.—For three years, beginning with the day of delivery, the contractor shall be responsible for the serviceability of the material, the workmanlike manufacture and assembling of the parts, with the understanding that the contractor is bound to bear all of the costs of manufacture or renewal which are the result of poor quality of the material or of the faulty method of manufacture or carelessness in the assembling of the parts.

Arbitration.—(Omitted.)

HOLLAND RAILWAY

SPECIFICATIONS FOR THE DELIVERY OF STEEL RAILS (1913)

1. Dimensions and Weight.—The rails must agree in form with the designs and the templets made from them. The profile must be preserved over the whole length, and no damage may be done to it in the cutting of the rails; at the ends of the rails the burrs must be removed.

The normal length of the rails shall be, at a temperature of 10° C.:

14 m for a rail height of 130 mm, profile H. IJ. S. M.

9.62 m for a rail height of 128 mm, profile S. S.

9.0 m for a rail height of 120 mm, local.

The number of rails of other lengths than normal to be delivered shall be given in the contract.

In rails of length of 9 m and less the allowable tolerance shall be ± 2 mm, that in rails of over 9 m in length ± 3 mm. In order that these measurements of length shall be made accurately, there shall be kept near the rail bed a steel tape, protected from the heat and the weather, and graduated in millimeters, with which the rule or tape used in measuring the lengths of rails may be compared. To the testing official shall be furnished all of the models or templets which are required in each measurement, and particularly in the measurement of the positions and dimensions of the tie-plate and other holes, and of the slopes of the base of the rail.

There will be allowed in the width of head a tolerance of 0.5 mm, in the width of base of 1 mm, in the position of bolt holes 0.5 mm at most.

The rails of normal length require no special marks, those of height of 130 mm and length of 13.93 m, those of height of 128 mm and length of 9.555 m, and those of height of 120 mm and length of 8.90 m to be used in curves must be painted red on the end face, while in all other rails the length is to be indicated in painted figures above the head and on the side of the web. Rails with sloping bases must be painted white on the end faces.

The normal weights per meter for the rail bar shall be—

38.6 kg for the height of 130 mm, profile H. IJ. S. M.
52 kg for the height of 130 mm, profile H. IJ. S. M., eccentric.
33.7 kg for the height of 128 mm, profile S. S.
25.6 kg for the height of 120 mm, local.

A tolerance in this weight will be allowed for partial lots of 2 per cent more or less, but the total actual weight of the whole lot shall be within 1 per cent of the normal weight.

Within these limits the rails shall be paid for according to actual weight. If below this weight, they shall be refused; if above this weight, they shall be accepted; but the contractor shall not be paid for the overweight.

2. Manufacture of the Rails.—The steel from which the rails are manufactured shall be of Martin, of Bessemer, or of the improved Thomas process.

In order to facilitate for the inspector the investigation of the steel, the manufacturer must at all times allow the former to examine all of the lists or tables in which the results of tests taken in the factory itself are entered day by day, and wherein an account is kept of the carbon content as well as of that of other qualities of the steel.

The ingots to be rolled must have the greatest possible cross section, and be so heavy that they furnish at least two rails of normal length with discards of not less than 0.50 m.

Before an ingot is put into the rolls it shall be carefully inspected on all sides, and all surface roughness, such as scale, porous spots, fins (schalen, schilfers, bladders, dorens), etc., shall be removed.

At the request of the inspecting official the heat numbers shall as far as necessary be stamped on some of the rails in easily visible figures. The rails shall, moreover, be provided with other marks upon request.

3. Quality of the Rails.—The rails must be sound and smooth; those rails showing traces of burning or of cracks or other faults of a harmful nature shall be refused. The ends must be completely sound and freed from the milling or sawing burr, so that the tie-plates may lie flat on the web faces.

The rails must be completely straight over the whole length. The straightening must be done by hand or steam presses with a slowly increasing pressure and not by hammering, so that there shall remain no visible marks of the gagging, either in the horizontal or in the vertical direction. In the base of the rail no curvature or fault will be tolerated. These requirements apply even more rigidly to the nonsymmetrical rail type H. IJ. S. M.

The rails must show the exact profile required, for which purpose the rolls after having rolled 1000 tons of rails at most must be inspected, and if any deviation be noticed, renewed.

The rails are to be milled at both ends, so that the end faces are clean and perpendicular to the axis of the rail bar; the burr shall be carefully removed with chisel or file.

It is expressly forbidden to reheat the rails, to hammer or to file them in order to cover up some fault of manufacture. Rails treated in such a way will be refused.

The rails shall be provided as far as necessary with holes in the web and base slope, the number, position, form, and dimensions of which are to be indicated on the proper drawings.

The holes must be bored; they must have clean and smooth surfaces, be perpendicular to the side of the web, and freed from the burr.

The slope of the base of some of the rails must be brought about by machining over length and breadth, and it shall be perpendicular to the lower base surface.

If the dimensions, condition, form, or position of these holes or slopes do not agree with the drawings the rails will be refused.

4. Testing of the Steel.—From the various heats used in rolling rails one test ingot may be taken, and the carbon and other content determined.

Not until after the first heat for rails has been rolled and then tested in regard to toughness, ductility in bending, and strength shall the limits be decided within which the carbon content and content of other constituents must be kept.

Bars of thickness of 20 by 20 mm, forged from the test ingot, must be capable of being bent cold without fracturing, so that the ends shall come together at a distance equal to five times the thickness.

In general, the material from which the rails are being manufactured shall exhibit the qualities of good and serviceable steel in all respects; it must be tough and ductile in bending and must show a dense, fine, and bright grain in the fracture.

5. Testing of the Rails.—The official charged with the tests shall after investigating the quality of the steel select a number of rails up to 1 per cent at most of the partial lot manufactured at that time, and belonging to the same heat, and subject them to the following tests:

(1) THE TENSILE TEST.—From the head of the rail bar a test bar is to be taken cold, of a uniformly circular cross section over a length of 200 mm at least, and of a diameter of 20 mm at least. It must withstand a tensile stress of at least 60 kg and at most 70 kg per square millimeter of the original cross section, while the elongation at the moment of fracture must be at least 15 per cent.

A rail bar notched 2 mm deep on the head and placed with the head on two immovable supports must be slowly broken by the application of pressure by means of a hand-screw press, and not by a power press. The rail shall be broken also in the reverse direction in like manner, the rail being notched on the base.

The fracture must exhibit a completely uniform, bright, and fine grain. In polishing and etching the fracture surface the steel must appear perfectly dense and free from slag and porous spots.

(2) THE TRANSVERSE BENDING TEST.—One-half of the rail bar broken in the manner above specified, resting on two immovable supports, which are to be placed at a distance of 1 m from one another, shall be subjected at the center to a weight of the following amount for five minutes:

20 000 kg for the rails of height 130 mm, profile H. IJ. S. M.
25 000 kg for the rails of height 130 mm, profile H. IJ. S. M., nonsymmetrical.
16 500 kg for the rails of height 128 mm, profile S. S.
13 000 kg for the rails of height 120 mm, profile local.

After removing the load there shall be no permanent deformation or bending.

The rail bar resting on the same supports must not break after having been subjected to weights of two and one-half times the preceding ones for the same length of time.

(3) THE DROP TEST.—The second half of the same rail bar must be able to withstand the first blow of a drop hammer of the following intensities:

4200 kgm for the rails of height 130 mm, profile H.IJ.S.M.
4900 kgm for the rails of height 130 mm, profile H.IJ.S.M. nonsymmetrical.
3900 kgm for the rails of height 128 mm, profile S. S.
3200 kgm for the rails of height 120 mm, profile local.

In this test the hammer tup falls at the center of the span. The amount of bending under the first blow must not exceed 65 mm; thereafter the test shall continue with blows of 1800 kgm until a total bending of at least 100 mm shall be attained without the rail breaking.

The hammer used in this test shall have a tup rounded with a radius of 5 cm, and may be raised higher in order to carry the test to destruction.

If in this test one of the rail bars does not fulfill the prescribed conditions, or the fracture exhibits faults in the quality of the steel, then a second rail bar is to be tested in the same way. If this second bar does not give satisfactory results, the whole lot of rails manufactured at the same time and of the same heat shall be rejected.

On the other hand, if the second rail bar withstand the test, then two more rail bars shall be subjected to the test; if they also fulfill the specifications of the test, then the whole lot shall be accepted; but if only one of the two fulfill the conditions of the test the whole lot shall be rejected.

In order that no differences may arise concerning the results of the tests the manufacturer shall have an official agent present, whenever an official of the railway administration undertakes a test, so that he may corroborate the results of the test.

A record of the result of the tests shall be made.

6. Templets.—(Here omitted.)

7. Identification Marks.—(Here omitted.)

8. Supervision.—The administrative board reserves to itself the right to supervise the manufacture of the rails through one or more officials.

The manufacturer is bound to give notice 14 days in advance of the day when the manufacture is to begin, and to furnish to the officials of test all information required both relating to the arrangement and use of the apparatus, tools, furnaces, etc., and to the manufacture itself.

These officials shall be charged night and day to oversee the manufacture in all particulars, and to undertake any investigations which may be necessary to insure a strict compliance with all of the provisions of these specifications. They reject the poor rails, which must be taken back without any claims for damages.

The investigation, the testing, and the weighing is done at the cost and risk of the manufacturer in his plant, where the accepted rails are stamped and the rejected ones are painted on both ends with red paint.

The delivery is to take place only during dry weather, and the rails shall lie before that time in dry, covered places, provided with a sufficient number of openings for the light. (From here on this paragraph is not complete.)

The weighing is done with 10 per cent of the rails of each partial lot for delivery.

(Other paragraphs follow dealing with the time of delivery, the power of the inspector, storing of the rails, rusting of the same during storing, etc., which are here omitted.)

9. The Factory.—It is expressly forbidden to assign any part of the contract for delivery to any other firm or contractor, or to have any part of the materials or articles contracted for manufactured in any other plant without the consent of the railway administration.

10. Default.—(Here omitted.)

11. Fines.—(Here omitted.)

12. Guarantee.—The manufacturer remains responsible for the rails for five years after delivery, counting from the time when the rails have been placed on the track. The time at which the guarantee begins is the date of the record of acceptance; during that period the manufacturer shall at the first request of the railway administration take back all rails in which any cracks or other faults manifest themselves, or which break, and replace them with other rails in accordance with these specifications.

If the manufacturer does not replace such rails within two months after notice has been given, the board shall have the right to buy at the cost of the manufacturer such rails wherever they deem proper.

13. Delivery and Penalties.—(Here omitted.)

14. Payment.—(Here omitted.)

SPECIFICATIONS FOR ROLLING STOCK, 1913 (BY LETTER)

A. Wheel Pairs for Locomotives.—The wheel pairs are to be delivered finished and ready for service. The materials to be used are the following:

(1) Axles, of Martin steel: Tensile strength at least 50 kg per square millimeter; elongation at least 18 per cent.

(3) Wheel centers, of cast steel: Tensile strength, 38 to 45 kg per square millimeter; elongation at least 25 per cent.

(4) Tires, of crucible steel: Tensile strength 70 to 90 kg per square millimeter; elongation at least 14 to 18 per cent; and the tensile strength of $(70+x)$ kilograms per square millimeter must be associated with an elongation equal to $(14-6\ x/20)$ per cent.

(7) The crank axles are to be of nickel steel. (See E.)

B. Wheel Pairs for Tenders.—The physical properties are indicated below:

(1) Axles, of Siemens-Martin steel: Tensile strength 50 kg per square millimeter; elongation 18 per cent.

(2) Wheel centers, of cast steel: Tensile strength 38 to 45 kg per square millimeter; elongation 25 per cent.

(3) Tires, special Martin steel: Tensile strength 65 to 80 kg per square millimeter; elongation 15 to 10 per cent; and the last material shall show an elongation of at least $(15-x/3)$ per cent with a tensile strength of $(65+x)$ kilograms per square millimeter. The phosphorus content of this special Martin steel shall be less than 0.04 per cent.

The wheel pair must be perfectly equilibrated.

C and D. Wheel Pairs for Passenger and Freight Cars.—The required physical properties are indicated below:

(1) Tires, of Martin steel: Tensile strength 60 to 75 kg per square millimeter; elongation at least 15 to 10 per cent. In this case the elongation associated with a tensile strength of 60 kg per square millimeter must be at least 15 per cent; that with a tensile strength, of 75 kg per square millimeter at least 10 per cent, and must have corresponding values for intermediate values of the tensile strength (linearly interpolated; this method of construing a requirement for the tensile test, when two values are given, as above, is used throughout this specification.)

(2) Axles, of Martin steel: Tensile strength at least 50 kg per square millimeter; elongation 18 per cent.

E. Crank Axles of Nickel Steel.—Nickel content must be 5 per cent, the tensile strength at least 60 kg per square millimeter, and the elongation at least 18 per cent.

F and G. Straight Axles for Locomotives, Tenders, Passenger and Freight Cars.—These shall be of Martin steel and must be annealed after forging. The required physical properties are indicated below:

Tensile strength at least 50 kg per square millimeter; elongation at least 18 per cent.

H. Locomotive Wheel Tires.—The required physical properties are given below:

Tensile strength 70 to 90 kg per square millimeter; elongation 14 to 8 per cent.

I. Locomotive and Tender Wheel Tires of Special Martin Steel.—The required physical properties are given below:

Tensile strength 65 to 80 kg per square millimeter; elongation at least 15 to 10 per cent.

The phosphorus content shall be less than 0.04 per cent.

J. Martin Steel Wheel Tires for Passenger and Freight Cars.—The physical properties are given below:

Tensile strength 60 to 75 kg per square millimeter; elongation at least 15 to 10 per cent.

Further Regulations for Wheel Pairs.—The wheel pairs shall be delivered ready for use. The journals must be finished, polished, and protected against damage and rust during transport. The axles and tires are to be made of Martin steel, the wheel centers and spring rings of rolled or hammered soft steel. The outer diameter of the finished wheel body as well as the inner diameter of the cooled tire shall be finished to the exact dimensions given in the design. The shrinkage measure shall be at the maximum 1 mm and the pressure with which the wheels are forced onto the axles at least 70 (metric) tons.

The axles, tires, disk centers, and spring rings are to be inspected before they are assembled. From every lot of 50 tires, 50 axles, or 100 disk centers shall be chosen one for purposes of test.

The tests to be carried out are: (*a*) For the axles, tensile tests; (*b*) for the tires, partly drop tests, partly tensile tests, according to the inspector; (*c*) for the disk centers, drop tests. From every test sample chosen for the tensile tests there shall be taken at four places indicated by the inspector or official of tests, four test specimens; two of these are to be prepared according to a design furnished to the company and sent to the central shops of the Dutch Railways at Haarlem, where they are to be tested. If this test does not furnish favorable results, a further test on the other two specimens shall be made in the company's shops.

The drop tests of tires and disk centers shall be made in accordance with the regulations of the Royal Prussian State Railways.

Special Regulations for the Furnishing of Wheel Tires.—The wheel tires shall be furnished unmachined. (For testing of tires see above.) The variation from perfect roundness in the tires may not be more than 2 per cent.

SWEDEN

STATE RAILWAYS

RULES FOR THE MANUFACTURE AND DELIVERY OF RAILS OF THE —— MODEL (MARCH, 1912)

Material.—1. Rails shall be made of steel produced by the ——— Martin method, or the ——— Bessemer method. The phosphorus content shall not exceed 0.075 per cent.

HARDNESS TEST.—2. The material shall have a tensile strength of at least 60 kg per square millimeter. In testing the hardness of the rail head with a hard steel ball of a diameter of 19 mm and a pressure of 50 000 kg, an impression should be obtained of a depth not less than 3.5 and not more than 5.5 mm. The finished rail shall sustain the following test at a temperature of +15° C:

3. The rail shall be laid, head upward, upon two supports of cast iron or steel, placed at a distance of 1 m from each other, firmly clamped to a bed (substructure) weighing at least 5 tons, and submitted to a blow, at the middle of the supports, of a weight of 1 metric ton falling from a height of 5 m, and then to repeated blows with the same weight from a height of 1.2 m until the bending of the rail shall amount to 100 mm. No trace of cracks or other defects should be visible.

Manufacture.—1. From both ends of the rail rolled from each ingot pieces of sufficient length shall be cut off so that the ends of the rail shall be completely free of defects. The piece taken from that end of the rail which corresponds with the upper end of the ingot shall be at least 2 m long.

2. The rails shall have an even and smooth surface and shall be free from flaws, cracks, and other defects of the surface. To repair or conceal such defects by hammering or other means is prohibited. Flaws of less than 1 mm in width may be chiseled away, but only on special permission by the inspector in each particular case, and in no case on the rail's ends or on the upper lateral roundings of the rail head.

3. Rails shall be rolled in strict compliance with the sketch. A deviation of ±0.5 mm in the height of the rail and the breadth of the head, and ±1 mm in the width of the base is allowed.

4. Rails shall be perfectly straight and free from warp. After cooling they shall not be heated any more, and only slight straightening may be undertaken, to be carried out carefully, so that the tools may leave no marks or impressions.

5. The end surfaces shall be plane and straight and perfectly perpendicular to the longitudinal axis of the rail. All cuts due to sawing or machining are to be carefully smoothed away.

6. Each rail shall be provided with two bored holes at each end in strict compliance with directions. The burrs due to boring shall be smoothed away carefully.

Length.—1. The length of the rails shall be —— m at a temperature of +15° C, with a permissible variation of ±3 mm.

2. In the case of rails for curves, —— per cent of the total lot shall be delivered in lengths of —— m. These rails are to be marked with white paint. Up to 5 per cent of the whole lot is to be delivered in lengths of —— m, which rails shall be marked on both ends with green paint.

Weight.—1. The rails shall have a normal weight of —— kg per meter, as provided in the contract. Deviations of ±2 per cent for an individual rail and of ±1 per cent

for the whole lot are permitted, but excess weight over the normal will not be paid for. In the case of underweight within the prescribed limits, the actual weight will be paid for. The contractors are responsible that the actual weight shall not fall below the specified limits.

Marking.—Each rail shall bear the name and stamp of the manufacturer, the year of manufacture, and the letters S. J., in letters and figures 20 mm high. Immediately after rolling each rail shall be stamped with the number of the heat from which it was rolled.

Inspection and Testing.—1. The manufacturer shall keep and furnish to the inspector an account of all heats employed in the rolling of rails.

2. A chemical analysis for carbon and phosphorus content shall be made of each heat (utslag), with a complete analysis of each tenth heat, or oftener, if the inspector shall deem it advisable.

3. A hardness and a drop test, as required above, shall be made on at least one rail of each heat, with a static tensile test as often as the inspector may consider it desirable.

4. If a rail does not comply with the specifications for drop test and hardness, as indicated above, two other rails shall be selected from the same heat and tested in the same way, and if neither of them fulfill the specifications, all of the rails rolled from that heat shall be rejected.

5. Each rail inspected and passed shall be stamped by the inspector with a special stamp; without this stamp rails shall not be accepted.

6. During the manufacture of the rails the inspectors shall have access to the plant where the manufacture is taking place, and the manufacturer is obliged to place at their disposal, without cost, not only the rails, tools, and apparatus, but also the men needed for the tests.

7. The manufacturer is obliged to notify at least —— in advance the supply bureau of the Royal State Railways Administration of the rolling of each lot of rails contracted for.

REGULATIONS FOR THE DELIVERY AND MANUFACTURE OF AXLES AND WHEELS FOR LOCOMOTIVES (1913)

The axles should be manufactured of first-class Martin steel, free from defects, in accordance with the best practice, from Swedish pig iron which is free from flaws and other defects.

Material for the axles shall have a tensile strength of at least 50 kg per square millimeter and an elongation of at least 20 per cent over 50 mm test length. The yield point must not be below 28 kg per square millimeter, and the reduction of area shall be at least 35 per cent of the original area. Axles shall be machined over their whole length and the ends polished. Materials for crank axles shall contain at least 3 per cent nickel and shall have a tensile strength of at least 55 kg per square millimeter and an elongation of at least 20 per cent over 50 mm test length. The yield point shall not be below 40 kg per square millimeter, and the reduction of area shall be at least 40 per cent of the original. Test specimens shall be taken from both crank ends of all crank axles in accordance with sketch number 5438. For straight axles there is required a test specimen from one axle of each heat. Axles shall be well annealed after forging and allowed to cool slowly. The journals shall be turned in the lathe. An axle which is delivered with the wheel must have the wheel seat worked smooth, and must have the diameter at the outer end less than that of the journals by 0.4 mm or less. The wheel seat of axles furnished without wheels shall be left rough and with 5 mm machining leeway, measured along the radius. The manufacturer of the axles must be one recognized by the Royal State Railway Administration.

The wheels shall be cast of soft Martin steel of the best possible quality in accordance with the specifications of the Royal State Railways, and they must be manufactured

carefully according to measure so that each counterweight, hub, etc., has the proper dimensions. The counterweights shall be turned to their proper thickness and the hubs of the wheels shall be turned smooth at both ends.

The spring rings shall be turned according to the profile and to the correct diameter. The holes in the wheels for the taps (tapparna) shall be bored in the mill after the wheels have been pressed on the axle.

The tires shall be made according to the special specifications. They should be put together in such a manner that the difference in carbon content should not be more than 0.05 per cent between the tires on the same axle or between the wheels of the same driving or coupling axle. They should be turned on both sides according to profile, with a shrinkage measure of 1/1000.

The end surfaces of the tires shall be machined smooth and be provided with grooves for the reception of the wheel and spring ring. The tires shall be machined on the tread surface after they have been mounted on the wheel. The diameter at the tread circle of a wheel set, mounted on the same coupling or driving axle, shall be the same. The hammering down of the opening for the spring rings shall be done carefully, especially at the groove.

The forcing of the axles onto the wheels shall be done in a hydraulic press with the greatest care, using a pressure of from 5 to 6 metric tons per centimeter of the inside diameter; a record of the process of the final forcing shall be sent to the machine-inspection bureau of the Royal Railways.

Driving and coupling axles shall be forged of nickel steel for which the regulations above for nickel steel for driving axles are applicable.

Test specimens are to be round and have a diameter of 10 mm.

(Paragraphs dealing with the marking of the various articles follow, which are here omitted.)

SPECIFICATIONS FOR ROLLING STOCK FOR THE STATE RAILWAYS (1912)*

Paragraph 4.—Chill cast-iron wheels are permissible only for freight cars without brakes, and cars with such wheels must only be employed on trains having a maximum speed of 45 km.

SPECIFICATIONS FOR THE FURNISHING OF AXLES FOR TENDERS AND FREIGHT CARS (1909)

Material.—The axles should be manufactured of sound, close-grained Martin first-class steel, manufactured according to the best methods from Swedish pig iron free from flaws or other defects.

The tensile strength of the steel should be at least 45 kg per square millimeter.

Manufacture.—The axles should be rolled entirely straight, round, and smooth, according to the drawings of the State Railways.

The part of the axle which contains the wheel seat is to be rolled with a diameter greater by 8 mm than that of the drawing, and the axle journal shall be polished smooth with emery.

Marking.—The axles shall be marked hot with the name of the manufacturer, name of the material, year of manufacture, number of manufacture, and heat number to which the axle belongs.

(Omitted are paragraphs dealing with the position and size of the letters to be used in the marking of the axles.)

Testing and Inspection.—It is the duty of the contractor to report to the Royal Railway machine-inspection bureau when all or any part of the axles are ready for inspection.

The inspector of the Royal State Railway shall, during the time of manufacture, have free admittance to the shops of the contractor to oversee the manufacture and examination of the materials which are used.

To the inspector shall be given a list of the axles which are ready for inspection, and in this list should be indicated number, material, heat number, carbon content, delivery number, date of order, for the different kinds of axles.

For examination of the quality of the axle material the inspector shall take from each lot furnished one test axle for every 50 axles or fraction thereof, and with the same shall be carried out an impact test with a fall hammer of 1000 kg and with a span between the points of support of the axle of 1.5 m. The height of fall is taken from 3 to 4 m for axles with a diameter at the center of 118 or 135 to 150 mm, respectively, and the axles shall for such blows bend, respectively, 200 or 180 mm without breaking or showing signs of cracks.

From the ends of the axle tested in the impact test shall be taken cold, test specimens, one from each end, with which a tensile test shall be carried out. If the axle passes these two tests, then the lot is accepted. In case this test is not met two new axles are taken out and are tested in the same way and the lot is accepted only if both of these axles pass the prescribed test.

Normal drop testing machines made according to the regulations of the Royal State Railways shall be used in all of these impact tests.

The contractor shall provide without cost the axles used in the tests, and shall also furnish the assistance which is necessary for the carrying out of the test.

(There are here omitted clauses dealing with the painting of axles.)

REGULATIONS FOR THE MANUFACTURE AND DELIVERY OF WHEEL TIRES (1908)

Material.—Wheel tires shall be manufactured of first-quality Martin steel with a tensile strength of at least 65 kg per square millimeter, having at least 14 per cent elongation, on a specimen 200 mm long with a diameter of 20 mm. The material shall be hard and homogeneous and free from blowholes, sponginess, etc.

Method of Manufacture.—Tires shall be well forged under the press or the steam hammer. The profile of the finished tires shall conform exactly to the drawing or sketch of the Royal Railway Administration. The tires shall be exactly round and free from eccentricity. The inner diameter must not deviate by more than 1 mm and the outer diameter by not more than 2 mm from the diameters prescribed in the drawings for each type of tire. The surface should be smooth and free from defects. Each tire shall, after rolling, be annealed and left to cool slowly.

(Paragraphs are here omitted dealing with the marking of the tires.)

Inspection and Testing.—It is the duty of the contractor to report to the Royal Railway machine-inspection bureau when the whole or part of the lot is ready for inspection. The inspector of the State Railway shall during the time of inspection have free admission to the shops of the contractor to oversee the manufacture and to test the material used.

To the inspector shall be given a list of those tires which are ready for testing, and on this list shall be indicated profile number and letter, number, material, heat number, carbon content, inner diameter, manufacture number, and date of ordering.

Before the tests are made the tires should be closely inspected and such be taken out which are found to be defective.

For the testing of the quality of the tire material the inspector shall take from each lot one test tire for every 50 tires or part thereof, and this tire shall be subjected to the impact and the tensile test.

In the impact test the tires shall support without breaking or showing signs of defects a blow of a fall hammer of impact work, 3000 kg m, and shall be capable of bending at least 8 per cent for tires with an inner diameter up to 750 mm, at least

12 per cent for tires with an inner diameter up to 1500 mm, at least 15 per cent for tires with an inner diameter over 1500 mm.

The tires are placed vertically under the fall hammer and the blows strike the tire through a block which corresponds to the profile of the tire. The tire is supported on a similar block. The inspector has the right to have this test carried to destruction with one-third of the test tires, and the breaking may be hastened by notching. The fracture shall show an even and close texture.

From the tire tested in the impact test shall be taken cold a tensile-test specimen which shall be tested in tension. The material must possess the tensile properties mentioned above.

If the tire passes the prescribed tests, the lot is accepted. If not, the inspector has the right to take out for further test 1 tire from every 10 tires, although at least 1 tire from each heat shall be tested again. Only tires of those heats are accepted from which all tires so retested have sustained the drop and tensile test.

Sharp edges on the test tires must be filed away before test.

The normal drop testing machine according to the specifications of the Royal State Railway Administration shall be used for the drop tests. The manufacturer shall without cost provide those tires which the inspector desires for testing, and he shall also without cost supply the labor and materials necessary for the carrying out of the test.

Guarantee.—The contractor must replace those tires which in the course of five years from the month of acceptance of the lot in question, due to defects in the material have to be machined down by an amount of 10 mm greater than that necessary to obtain the required profile.

REGULATIONS IN REGARD TO THE MANUFACTURE OR FORGING OF WHEELS FOR CAR AXLES (1908)

Dimensions of wheels should be exactly those that the Royal State Railways indicate.

The wheel centers must be made entirely of (smidt järn) wrought iron and should be completely forged together both in the hub and the tire without burning at the spokes. The hub shall be turned on the sides, and the circumference shall be turned smooth to the diameter that is necessary. The tire is machined on the side and also on the outer circumference, and the diameter of the latter shall agree with the dimension given in the sketch, and unevenness must not show after turning and boring. Each wheel center must be manufactured so carefully that the center of gravity lies in the geometrical axis of the wheel, and examination in this respect shall take place on each wheel before forcing wheels onto the axles. This examination takes place by supporting the wheel upon a special axle which must rotate upon plane or conical supports; the difference in weight between the wheel centers which are selected for one and the same axle must not exceed 1 kg.

The wheels should be pressed onto the axles with a hydraulic press with a pressure of —— kg. Both of the wheels should be pressed on at the same time.

The wheel tires shall be of first quality Martin steel and manufactured in accordance with the regulations regarding the manufacture and delivery of wheel tires, and in case they are not manufactured by the contractor furnishing the axles the manufacturer of the wheel tires must be responsible for the delivery of the axles directly to the Royal State Railways. In case they can not be obtained from a domestic manufacturer they must only be ordered from such foreign manufacturers as are approved by the Royal State Railway Administration.

The tires should be turned completely cylindrical at the inner circumference and with a shrinkage measurement of 0.001 and shall be fastened to the wheels by means of spring rings.

The difference in carbon content of the wheel tires for the same axle must not exceed 0.05 per cent.

(From here on the text, which deals with the marking and balancing of the wheel sets, is not completely reproduced.)

The turning of the tires shall not take place until after the wheels have been forced onto the axles. After the wheels have been pressed onto the axle it shall be placed with the journals upon two horizontal supports and must then be in equilibrium without tendency to roll in either direction.

The center of the wheels after the manufacture shall be stamped with the name of the manufacturer and the material and also the year of manufacture in large and plain letters.

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