

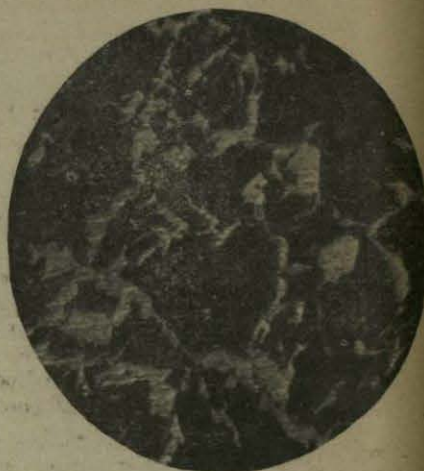
PHOTO-MICROGRAPHS OF TWO RAILS AND CEMENT BAR.



No. 65.—Steel rail as rolled. Interior of heads. Transverse section. Magnification 150 diameters.

Carbon,	0.303
Silicon,	0.042
Sulphur,	0.044
Phosphorus,	0.055
Manganese,	0.295

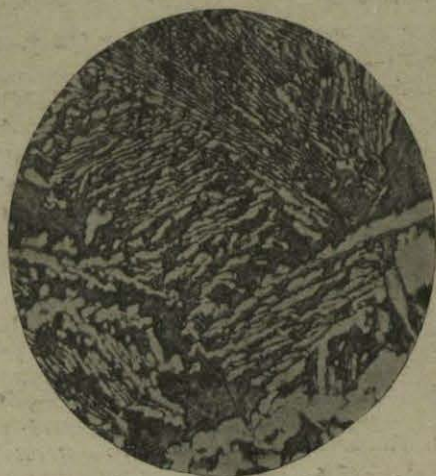
Example of low Carbon and low Manganese steel rail.



No. 66.—Steel rail as rolled. Transverse section. Magnification 150 diameters.

Carbon,	0.489
Silicon,	0.084
Sulphur,	0.050
Phosphorus,	0.060
Manganese,	0.970

Fairly high Carbon and high Manganese rail.



No. 67.—Cement bar. Showing Pearlite and Cementite. Magnification 150 diameters.

APPENDIX I.

SPECIFICATIONS.

AMERICAN SPECIFICATIONS.

THE standardisation of specifications for steel rails, tires, axles, castings, forgings, structural steel, boiler plates, &c., has received considerable attention since 1882, when the International Association for Testing Materials was originated.

The American section of this Association was organised in 1898, and was superseded by the American Society for Testing Materials in 1902. This Society publishes a Year-Book devoted chiefly to the publication of the standard specifications and standard methods adopted by the Society.

The following specifications have been adopted by this Society, and it will be seen that, with regard to chemical composition, the amount of Carbon is not generally specified when a tensile test is required, the percentage of constituents other than Phosphorus and Sulphur being left to the manufacturer. In some cases, however, the amounts of Silicon and Manganese are also specified.

It has been recognised that, for the same chemical composition, steel produced in the Basic open hearth is softer than acid Bessemer steel, and it is quite safe to take higher Carbons, especially if, at the same time, a lower percentage of Phosphorus is insisted upon.

AMERICAN STANDARD SPECIFICATIONS, TEST PIECES, AND METHODS OF TESTING IRON AND STEEL, ADOPTED BY COMMITTEE NO. 1 OF THE AMERICAN SECTION OF THE INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

The Committee recommends the following as the general requirements which international specifications should include:—

Process of Manufacture.—The process or processes of manufacture of a steel for a given purpose should be specified, but the details of the process should be left to the manufacturer, as a satisfactory product is produced by methods of manufacture varying in different countries.

The proportions of certain of the chemical constituents, especially Sulphur and Phosphorus, should be specified to be within certain limits, and limits should be prescribed to all physical properties which determine the suitability of the steel for the purpose intended.

The number and location of the test pieces should also be specified, the general methods of determining the physical properties specified given, and how the sample for chemical analysis should be taken.

The specifications should also contain clauses governing the required finish and branding of the material, and a clause granting the inspector the necessary facilities to see that the provisions of the specification are carried out.

For steel rails, the following clause may be inserted:—

“The entire process of manufacture and testing shall be in accordance with the best current practice, special care being given to the following instructions:—Ingots shall be kept in a vertical position in pit heating furnaces; no bled ingots shall be used; sufficient material shall be discarded from the top of the ingot to insure sound rails.”

Chemical Requirements.—The general recommendations of the Committee as regards chemical composition are embodied in the tabulated specifications, but it is recommended that when the tensile strength is specified the Carbon shall be omitted, as a number of cases have occurred where the tensile strength specified could not be obtained by keeping the Carbon, and in some cases Manganese and Silicon, within the required limits.

It is considered that the chemical composition of the steel, other than limiting the amount of Phosphorus and Sulphur, may be left to the manufacturer if the physical properties required are properly specified.

Tensile Strength.—Tensile strength, which, except in the case of steel rails, is always required, is specified in order to insure the necessary strength in the material.

Yield Point and Elastic Limit.—The elastic limit is considered very important as being the true index of the resistance to working stress, but as it is not practicable in rapid commercial work to accurately determine this, the yield point is required with the tensile strength in all cases, with the exception of rails.

Elongation.—It is recommended that for structural steels, boiler plate and rivet steel, and splice bars the percentage of elongation be measured in 8 inches, and for castings, axles, forgings, and tires in 2 inches.

Contraction of Area.—This test is recommended for castings, axles, and forgings where the tensile strength is determined on a turned test specimen. A turned test specimen is also used for tires, but here the test is considered unnecessary for the high Carbon steel used, as the tires are very seldom annealed.

This test is a valuable one as an indication of the physical state and uniformity of the steel. Steel of good quality, which has received proper treatment as regards heating and mechanical work, always gives a good contraction of area in proportion to its tensile strength.

Bending Tests.—The cold bending tests are to be made on untreated bending specimens cut from the finished material.

The cold bending test, like contraction of area, indicates the physical condition of the metal. Steel capable of severe cold bending always shows high contraction of area and *vice versa*.

Drop Tests.—These are recommended for axles, tires, and rails.

An axle must stand a certain number of blows from specified heights without rupture, the first blow to give a certain deflection which should not subsequently be exceeded.

A tire must stand, without breaking or cracking, successive blows from increasing heights until it shows a minimum deflection equal to $D^2 \div (40T^2 + 2D)$, where D is the internal diameter of the tire, and T the thickness at centre of tread.

A rail must not break or crack from a single blow from heights varying with the section of the rail.

It is considered that materials which will be subjected to shocks when in actual use should be tested by impact.

The Test Pieces and Methods of Testing Specified.—For steel castings, axles, forgings, and tires a standard turned test specimen is recommended $\frac{1}{2}$ inch diameter and 2 inches gauged length.

Tensile Specimens.—For the sheared plates used in structural steel for buildings, structural steel for bridges and ships, and in open hearth plate steel a standard test specimen 18 inches long, $1\frac{1}{2}$ inches wide, the thickness of the plate, of 8 inches gauged length is recommended. The parallel portion should not be less than 9 inches.

Methods for Tensile Tests.—When the yield point is required it may be determined by the careful observation of the drop of the beam or halt in the gauge of the testing machine.

The following are the dimensions of TEST SPECIMENS recommended:—

Bending Test.—For castings and forgings 1 inch wide by $\frac{1}{2}$ inch thick.

With structural steel for buildings, and for bridges and ships, and with open hearth plate and rivet steel, the width should be $1\frac{1}{2}$ inches if possible, and if the thickness of material is $\frac{3}{4}$ inch or less, the specimen should have the natural rolled surface on two opposite sides, but with material more than $\frac{3}{4}$ inch thick the specimen may be $\frac{1}{2}$ inch thick.

Methods for Bending Tests.—The bending test may be made by pressure or by blows.

Methods for Drop Test.—The following details are recommended:—

(a) **Rails.**—Pieces tested should not be more than 6 feet long. They should be placed head upwards on solid supports 3 feet apart. The anvil block should weigh at least 20,000 lbs., and the supports should be a part of, or firmly secured to, the anvil. The tup should weigh 2,000 lbs., and the striking face should have a radius of not more than 5 inches.

(b) **Tires.**—These should be placed vertically under the drop, in a running position, on a solid foundation of at least 10 gross tons in weight, and subjected to successive blows from a tup (2,240 lbs.) falling from increasing heights until the required deflection is obtained.

(c) **Axles.**—Axles should be placed on supports 3 feet apart, in such a position that the top will strike the axle midway between the ends.

Weight of anvil,	17,500 lbs.
Weight of tup,	1,640 lbs.
Radius of supports and striking face of tup in direction of the axis of the axle,	5 inches.

The anvil should be free to move in a vertical direction, and is supported by twelve springs.

The following is a summary of the principal points recommended by the Committee for American specifications, and appended are specifications in tabulated form, showing the detailed tests, both chemical and mechanical, for different classes of material:—

AMERICAN STANDARD SPECIFICATIONS.

Axles,	Process of manufacture, percentage of P, S, and Ni, tensile strength, yield point, elongation, contraction of area, drop test.
Tires,	Process of manufacture, percentage of Mn, Si, P, S, tensile strength, elongation, contraction of area, drop test.
Castings,	Process of manufacture, percentage of P and S, tensile strength, yield point, elongation, contraction of area, drop test, percussion test, bending test.
Forgings,	Process of manufacture, percentage of P, S, Ni, tensile strength, yield point, elongation, contraction of area, bending test.
Rails,	Process of manufacture, percentage of C, Si, P, Mn, drop test.
Structural Steel— Bridges & Ships, }	Process of manufacture, percentage of P and S, tensile strength, yield point, elongation, bending tests.
Structural Steel— Buildings, }	Process of manufacture, percentage of P, tensile strength, yield point, elongation.
Boiler Plate and Rivet Steel, }	Process of manufacture, percentage of P, S, and Mn, tensile strength, yield point, elongation.
Splice Bars,	Process of manufacture, percentage of C, P, and Mn, tensile strength, yield point, elongation, bending test.

TABLE CIV.—STANDARD AMERICAN SPECIFICATIONS.

	Process of Manufacture.	Percentage of Elements Specified.	Tensile Strength.	Yield Point.	Elongation.	Contraction of Area.	Drop Test.					
							Weight.	Distance between Supports.	Diameter Axle at Centre.	No. of Blows.	Drop in Feet.	Deflection in Inches.
Axles, NI Steel.	Open Hearth.	P, max. .06 S, " .06 { P, " .04 S, " .04 { NI, " 3-4	Lbs. per sq. in. 80,000 80,000	40,000 50,000	20% in 2" 25% in 2"	25% 45%	Lbs. 1640	Feet. 3	Inches. 4 1/2 4 3/4 4 1/2 4 1/2 5 1/2 5 1/2	5 5 5 5 5 7	5 1/2 8 1/2 8 1/2 8 8 7 1/2	Without rupture and without exceeding, as result of first blow, deflection given.
Tires.	Open Hearth	Min, max. .75 Si, " .35 P, " .05 S, " .05	105,000 115,000	{ Passenger } { engine } { Goods } { engine }	12% in 2" 10% in 2"	16% 14%	Lbs. 2240				Tire in running position—blows from increasing heights until deflection. Where D = int. diam. T = thickness at centre of tread.	
Castings,	Open Hearth, Crucible, or by any other approved process.	P, max. .05 S, " .05	80,000 70,000 60,000	35,000 31,500 27,000	15% in 2" 18% in 2" 22% in 2"	20% hard. 25% medium. 30% soft.	For small or unimportant castings—in place of tensile test—test to destruction.					Bending Test.—Test piece 1" x 1/2", bent cold round curve 1" diam. without fracture—130° for soft castings, 90° for medium castings.
Forgings—Soft Steel, Carbon Steel not annealed, Carbon Steel annealed,	Open-Hearth, Crucible, or Bessemer.	P, max. .10 S, " .06 " .04	58,000 75,000 80,000	29,000 37,500 40,000 Elastic limit.	28% in 2" 18% in 2" 22% in 2"	35% 30% 35%						Bending Test.—Test piece 1" x 1/2", shall bend cold 180° without fracture—1/2" For soft steel—round diam. 1/2" For carbon steel—not annealed. 1 1/2" For carbon steel—from forging over 20" dia. 1 1/2" For carbon steel—from forging under 20" dia.

BRITISH STANDARD SPECIFICATIONS.

By the kind permission of the Engineering Standards Committee, I am permitted to give particulars of the principal British Standard Specifications so far as they relate to railway and structural materials. It will be seen that, with regard to chemical composition generally, they have followed the American practice in usually omitting to specify any percentage of Carbon when a tensile test is required, leaving the percentage of constituents other than Phosphorus and Sulphur to the manufacturer. In some cases limits for Silicon and Manganese are specified, and, generally, the process of manufacture is stated. The usual tensile tests, with elongation, are required, and in some cases cold bending tests, both on the untreated and quenched material, are specified.

Drop Tests.—These are required for rails, axles, and tires.

Rails.—The drop test for these varies with the section and weight of the rails. For flat-bottom rails pieces 5 feet in length are placed on bearings 3 feet apart, and for 70 lbs. to 100 lbs. on bearings 3 feet 6 inches apart. For bull heads, 5 feet lengths are taken, and bearings are 3 feet 6 inches apart. The striking face of the tup in each case must be rounded to a radius of not more than 5 inches. The following tables give details of tests for different rails—

FLAT BOTTOM RAILS.

No. of "B.S." Section and Nominal Weight of Rail per Yard in Lbs.	Falling Weight Test.		
	Weight of Tup.	Centres of Bearings.	Drop.
	Cwts.	Feet.	Feet.
20,	5	3	8
25,	5	3	9
30,	10	3	10
35,	10	3	12 1/2
40,	10	3	15
45,	15	3	15
50,	15	3	15
55,	15	3	17 1/2
60,	20	3	20
65,	20	3	20
70,	20	3 1/2	20
75,	20	3 1/2	20
80,	20	3 1/2	22
85,	20	3 1/2	24
90,	20	3 1/2	26
95,	20	3 1/2	28
100,	20	3 1/2	30

BULL HEAD RAILS.

No. of "B.S." Section and Nominal Weight of Rails per Yards in Lbs.	FALLING WEIGHT OF TEST.					
	First Blow.			Second Blow.		
	Drop.	Deflection		Drop.	Deflection	
		From	To		From	To
	Feet.	Inch.	Inches.	Feet.	Inches.	Inches.
60,	5	1	1 ⁵ / ₈	10	3	3 ³ / ₄
65,	5	1	1 ¹ / ₄	12	3	3 ³ / ₄
70,	6	1	1 ³ / ₅	12	3	3 ³ / ₄
7 ¹ / ₂ ,	6	1	1 ⁵ / ₈	12	3	3 ³ / ₄
80,	6	1	1 ⁵ / ₈	15	3	4
85,	6	1	1 ³ / ₈	15	3	4
90,	7	1	1 ¹ / ₄	20	3	4 ¹ / ₄
95,	7	1	1 ³ / ₈	20	3	4 ¹ / ₄
100,	7	1	1 ³ / ₈	20	3	4 ¹ / ₄

Axles.—Locomotive straight axles have to 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 2,240 lbs. as specified below.

The axle is to be turned after the first and third blow, and is to be broken after testing, both in the centre and at the journals.

Diameter of Axle at Centre.	Number of Blows.	Height of Fall, in Feet.	Distance Apart of Bearings.	
			Ft.	Ins.
Under 4 inches,	5	16	3	0
4 inches and under 4 ¹ / ₂ inches,	5	18	3	6
4 ¹ / ₂ " " 4 ¹ / ₂ " "	5	20	3	6
4 ¹ / ₂ " " 4 ³ / ₄ " "	5	22	3	6
4 ³ / ₄ " " 5 " "	5	24	3	6
5 " " 5 ¹ / ₄ " "	5	24	4	0
5 ¹ / ₄ " " 5 ¹ / ₂ " "	5	28	4	0
5 ¹ / ₂ " " 5 ³ / ₄ " "	5	28	4	6
5 ³ / ₄ " " 6 " "	5	32	4	6
6 " and over,	5	35	5	0

In the case of carriage and waggon axles, the following drop tests are specified, the bearings resting on a solid foundation, as in the case of locomotive axles:—

Diameter of Axle at Centre.	Number of Blows.	Height of Fall, in Feet.	Distance Apart of Bearings.	
			Ft.	Ins.
Under 3 ³ / ₄ inches,	5	15	3	0
3 ³ / ₄ inches and under 4 inches,	5	16	3	0
4 " " 4 ¹ / ₂ " "	5	18	3	6
4 ¹ / ₂ " " 4 ¹ / ₂ " "	5	20	3	6
4 ¹ / ₂ " " 4 ³ / ₄ " "	5	20	3	6
4 ³ / ₄ " " 5 " "	5	24	3	6
5 " " 5 ¹ / ₄ " "	5	24	4	0
5 ¹ / ₄ " " 5 ¹ / ₂ " "	5	28	4	0
5 ¹ / ₂ " " 5 ³ / ₄ " "	5	28	4	6
5 ³ / ₄ " " 6 " "	5	32	4	6
6 " and over,	5	35	5	0

Tires.—A locomotive tire has to stand the following test:—The tire is to be placed in a running position, with the tread resting on a block of metal of not less than 5 tons in weight, supported on a rigid concrete foundation, and must withstand, without fracture, blows from a falling weight of 2,240 lbs. The weight is to be allowed to fall freely from heights of 10, 15, and 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 centre of the tread as rolled, in inches:—

Class C.	Class D.
Tensile Breaking Strength, 50 to 55 tons per square inch.	Tensile Breaking Strength, 56 to 62 tons per square inch.
$\frac{d^2}{50t^2}$	$\frac{d^2}{55t^2}$

The tests for carriage and waggon tires are the same as regards the falling weight and height, until the following deflections are shown :—

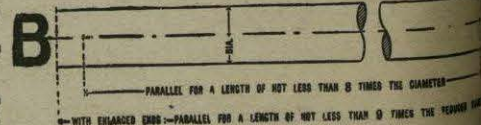
Class B. Tensile Breaking Strength, 42 to 48 tons per square inch.	Class C. Tensile Breaking Strength, 50 to 55 tons per square inch.	Class D. Tensile Breaking Strength, 56 to 62 tons per square inch.
$\frac{d^2}{45 t^2}$	$\frac{d^2}{50 t^2}$	$\frac{d^2}{55 t^2}$

The following tables give a summary of various British Standard Specifications, but full particulars as to detailed requirements are obtainable only from the following publications of the Engineering Standards Committee, which can be obtained at their offices, 28 Victoria Street, Westminster, S.W. :—

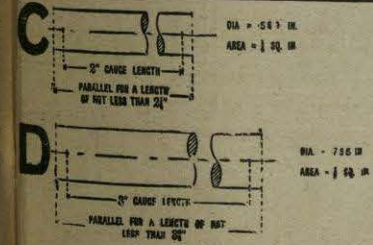
- No. 2. *Tramway Rails and Fishplates.*
- " 9. (Revised July, 1909) *Bull-head Railway Rails.*
- " 11. (" July, 1909) *Flat-bottom Railway Rails.*
- " 13. (" September, 1910) *Structural Steel for Shipbuilding.*
- " 14. (" March, 1907) *Structural Steel for Marine Boilers.*
- " 15. (" August, 1912) *Structural Steel for Bridges and General Building Construction.*
- " 24. (" 1911) *Railway Rolling Stock Materials.*
- " 29. (" November, 1909) *Ingot Steel Forgings for Marine Purposes.*
- " 30. *Steel Castings for Marine Purposes.*
- " 47. (Revised December, 1914) *Steel Fishplates for Bull-head and Flat-bottom Railway Rails.*
- " 64. *Steel Fishbolts and Nuts for Railway Rails.*

1	2	3	4	5	6	7
LINE.	MATERIAL.	TENSILE TESTS.				Number of Tests.
		Tensile Breaking Strength. Tons per Square Inch.	Minimum Extension per cent. on Standard Test Piece.	Standard Test Piece.	Yield Point per cent. of Ult. Tensile Strength.	
24	For Locomotive Frames, .	24-28	27 (c)	B or F	—	2 each cast, . . .
25	Do., . . .	24-28	27 (c)	B or F	—	Do., . . .
26	Carriage and Waggon Underframes, .	24-28	27 (c)	B or F	—	1 each cast or 25 tons, . . .
27	Do. do., . . .	24-28	27 (c)	B or F	—	Do., . . .
28	Bridges, A Steel, . . .	25-30	25 (e)	B or F	—	1 each cast, . . .
29	General Building Construction, A Steel, . . .	25-30	25 (e)	B or F	—	Do., . . .
30	Ships,	25-30	25 (e)	B or F	—	1 each charge, . . .
31	Locomotive Boilers, . . .	24-28	25 (c)	B or F	—	2 each cast, . . .
32	Marine Boilers, . . .	26-30	25 (c)	B or F	—	2 each charge, . . .
33	For Bull-head (railway), . . .	40-48	15	C or D	—	1 each 100 tons, . . .
34	Flat-bottom (railway), . . .	40-48	15	C or D	—	Do., . . .
35	Tramway,	40 min.	10½	C or D	—	Do., . . .
36	For Locomotive Crank Axles, . . .	30 min. 35 min. (oil hardened)	25 20	C or D	50	1 each web, . . .
37	Do.,	30 min. 35 min. (oil hardened)	25 20	C or D	50	Do., . . .
38	Loco. Straight Axles, . . .	35-40	25-20	C or D	50	2 per cent., but at least 1 each cast, . . .
39	Do.,	35-40	25-20	C or D	50	Do., . . .
40	Carriage and Waggon Axles, . . .	35-40	25-20	C or D	50	Do., . . .
41	Do.,	35-40	25-20	C or D	50	Do., . . .

- (c) When tested on a Gauge length of 4 dias. (Test piece F) elongation shall be not less than 32 per cent.
- (e) When tested on a Gauge length of 4 dias. (Test piece F) elongation shall be not less than 30 per cent.
- (g) Whichever is least.
- (h) When number of bars from one charge exceeds 15, one additional test for each further 15 or portion thereof. In round bars of 1½ ins. dia. and under, the number shall be 50 in place of 15.
- (i) When weight of bars exceeds, from one charge, 10 tons, one additional test for each further 10 tons or portion thereof.

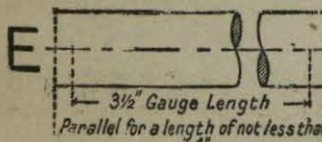


8	9	10	11	12	13	14	15	16	
Size of Test Piece.	Internal Radius of Bend, in Inches.	Angle of Test, in Degrees.	Number of Tests.	PROCESS OF MANUFACTURE.	PERCENTAGE OF IMPURITIES.			LINE.	
					Phos. phorus.	Sulphur.	Silicon.		
COLD BENDS.		HOT FLANGING TESTS.		<p>The rivet shank to be bent cold, as shown in sketch.</p> <p>The rivet head to be flattened as shown in sketch until 2½ times the diameter of shank without crack at edges.</p>	Open hearth, Acid or Basic, . . .	·06	·06	—	24
					Do., . . .	Not required.	—	—	25
					Do., . . .	·06	·06	—	26
					Do., . . .	Not required.	—	—	27
					Do., . . .	·06	·06	—	28
					Do., . . .	·06	·06	—	29
					Do., . . .	Not required.	—	—	30
					Open hearth, Acid, . . .	·05	·05	—	31
					Open hearth, Acid or Basic, . . .	Not required.	—	—	32
No bend tests, but tup test as given on pp. 495 and 496.					Open hearth or Bessemer, (k) Acid or Basic, (m)	·075 Acid or Basic.	·08	·10	33
					(k) Do., . . . (n)	·07 Acid or Basic.	·07	·10	34
					(l) Do., . . . (m)	·08 Acid or Basic.	·08	·10	35
8" long x 1.25" square.	1.25	90, and ends brought together,	1 cold each web, (g)	Open hearth, Acid, . . .	·035	·035	—	36	
Do., . . .	1.25	Do., . . .	Do., . . .	Do., . . .	Not required.	—	—	37	
Do., . . .	1.25	Do., . . .	1 cold, . . . (o)	Do., . . .	·035	·035	—	38	
Do., . . .	1.25	Do., . . .	Do., . . . (o)	Do., . . .	Not required.	—	—	39	
Do., . . .	1.25	Do., . . .	Do., . . . (o)	Do., . . .	·035	·035	—	40	
Do., . . .	1.25	Do., . . .	Do., . . . (o)	Open hearth or Bessemer, Acid, . . .	Not required.	—	—	41	



- (k) Also specified { Carbon, '35 to '50. Manganese, '70 to 1'0.
- (l) Also specified { Carbon, '40 to '55. Manganese, '70 to 1'0.
- (m) Carbon determinations of each cast required.
- (n) Carbon and Phosphorus determinations of each cast required.
- (o) Only for orders of 15 axles and under when drop test is not taken.
- (g) For round webs, 1 each end of axle.

LINE	MATERIAL	TENSILE TESTS					Number of Tests
		Tensile Breaking Strength, Tons per Sq. Inch	Minimum Extension per cent. on Standard Test Piece	Standard Test Piece	Yield Point per cent. of U.L. Tensile Strength		
42	For Loco. Tires, Class C,	50-55	13-11	C	—	2 per cent., but at least 1 each cast,	
43	Do., Class D,	56-62	10-8	C	—	Do.,	
44	Carriage and Waggon Tires, Class B,	42-48	18-15	C	—	Do.,	
45	Do. do.,	42-48	18-15	C	—	Do.,	
46	Do., Class C,	50-55	13-11	C	—	Do.,	
47	Do. do.,	50-55	13-11	C	—	Do.,	
48	Do., Class D,	56-62	10-8	C	—	Do.,	
49	For Locos., Blooms, Class A, special, case-hardened,	Up to 27	25	C or D	—	1 each cast,	
50	Do., Forgings, do.,	Up to 27	25	C or D	—	2 per cent., but at least 1 each cast,	
51	Do., Blooms, Class B, ordinary,	25-32	27-20	C or D	—	1 each cast,	
52	Do., Forgings, do.,	25-32	27-20	C or D	—	2 per cent., but at least 1 each cast,	
53	Do., Blooms, Class C, special, without wearing surfaces,	32-37	25-20	C or D	50	1 each cast,	
54	Do., Forgings, do.,	32-37	25-20	C or D	50	2 per cent., but at least 1 each cast,	
55	Do., Blooms, Class D, special, with wearing surfaces,	40-45	20-15	C or D	50	1 each cast,	
56	Do., Forgings, do.,	40-45	20-15	C or D	50	2 per cent., but at least 1 each cast,	
57	Do., Blooms, Class E, Boiler Forgings,	26-32	28-22	C or D	—	1 each cast,	
58	Do., Forgings, do.,	26-32	28-22	C or D	—	2 per cent., but at least 1 each cast,	
59	Do., Marine work,	28-40 Not more than 4 tons between any max. and min. specified.	29-17	C or D	—	At least 1 each forging, small forgings 5 per cent. of the order.	
60	Do.,		Do.,	C or D	—	Do.,	
61	Do.,		Do.,	C or D	—	Do.,	
62	For Locos., General Castings,	35 min. (r) 26 min. (s)	10 (r) 15 (s)	C or D	—	1 each cast,	
63	Do., Large or Important Castings,	35 min. (r) 26 min. (s)	10 (r) 15 (s)	C or D	—	Do.,	
64	Do., Wheel Centres,	26 min.	15	C or D	—	Do.,	
65	Do., Marine Work, Grade A,	35-40	15	C, D, or E	—	At least 1 each charge (p), if casting made from more than 1 charge, at least 4.	
66	Do. do., B,	26-35	20	C, D, or E	—		
67	Do. do., C,	26-35	15	C, D, or E	—		
68	Do. do., D,	—	—	—	—		



Dia. = .977 in.
Area = 3/4 sq. in.

- (p) Small castings, 1 for each pouring head.
- (r) For castings with wearing surfaces.
- (s) For castings without wearing surfaces.
- (u) For waggon wheel centres, 1 each cast.



LINE	Size of Test Piece	Radius of End in Inches	Angle of Test in Degrees	Number of Tests	PROCESS OF MANUFACTURE	PERCENTAGE OF IMPURITIES			LINE
						Phosphorus	Sulphur	Silicon	
42	—	—	—	—	Open hearth, Acid,	.035	.035	—	42
43	—	—	—	—	Do.,	.035	.035	—	43
44	—	—	—	—	Do.,	.035	.035	—	44
45	—	—	—	—	Open hearth or Bessemer, Acid,	Not required	—	—	45
46	—	—	—	—	Open hearth, Acid,	.035	.035	—	46
47	—	—	—	—	Open hearth or Bessemer, Acid,	—	—	—	47
48	—	—	—	—	Open hearth, Acid,	.035	.035	—	48
All tires are required to stand a falling weight test, which varies with the internal diameter of the tire, see pp. 497 and 498.									
49	9" long x 1.25" square,	1.25	90 and ends brought together,	1 cold each cast,	Open hearth, Acid or Basic,	.05	.05	—	49
50	Do.,	1.25	Do.,	2 per cent. cold, but at least 1 each cast,	Do.,	.05	.05	—	50
51	Do.,	1.25	Do.,	1 cold each cast,	Do.,	.06	.06	—	51
52	Do.,	1.25	Do.,	2 per cent. cold, but at least 1 each cast,	Do.,	.06	.06	—	52
53	Do.,	1.25	Do.,	1 cold each cast,	Open hearth, Acid,	.035	.035	—	53
54	Do.,	1.25	Do.,	2 per cent. cold, but at least 1 each cast,	Do.,	.035	.035	—	54
55	Do.,	1.25	Do.,	1 cold each cast,	Do.,	.035	.035	—	55
56	Do.,	1.25	Do.,	2 per cent. cold, but at least 1 each cast,	Do.,	.035	.035	—	56
57	Do.,	1.25	Do.,	1 cold each cast,	Do.,	.05	.05	—	57
58	Do.,	1.25	Do.,	2 per cent. cold, but at least 1 each cast,	Do.,	.05	.05	—	58
59	1" wide x .75" thick,	Up to 32 tons max. tensile, .25 in.	180	At least 1 cold each forging,	Open hearth, Acid or Basic,	—	—	—	59
60	Do.,	Above 32 up to 36 tons max. tensile, .375 in.	180	Do.,	Do.,	—	—	—	60
61	Do.,	Above 36 up to 40 tons max. tensile, .625 in.	180	Do.,	Do.,	—	—	—	61
62	9" long x 1" diameter,	1.25	90	1 cold each cast, (s)	—	.07	.07	—	62
63	Do.,	1.25	90	1 cold each casting, (s)	—	.07	.07	—	63
64	Do.,	1.25	90	1 cold each wheel centre, (u)	—	.07	.07	—	64
65	1" wide x .75" thick,	1.0	60	At least 1 cold each charge (p), if casting made from more than 1 charge, at least 4.	Open hearth, Acid or Basic,	—	—	—	65
66		1.0	120		Do.,	—	—	—	66
67		1.0	90		Do.,	—	—	—	67
68	Do.,	—	—	—	Do.,	—	—	—	68

All the tests given in the above tables are reconsidered by the Committee every year, and consequently are liable to be altered from time to time.

The International Association for Testing Materials have recently published a comparative summary of specifications for structural steel, rails, and fish plates, based on Standard Specifications published in the respective countries by Engineering Standards Committee, the American Society for Testing Materials, and the Deutsche Verband für Materialprüfungen der Technik, and they are appended

TABLE CVI.—SPECIFICATIONS

		Germany.	Great Britain.	
			Open Hearth.	Open Hearth or Bessemer.
1	Material	Siemens-Martin or Bessemer (Thomas).	Plates, rivets, and sectional material for bridges; plates and rivets for general building construction.	Sectional material for general building construction.
2	Finish	Smooth, free from cracks, blisters, and defective edges.	Free from cracks, surface flaws, laminations, &c.	
3	Chemical Analysis and Certificate	...	Of each cast upon request of purchaser.	
4	Chemical Composition	...	Bridges, per cent.	Building Construction, per cent.
			P, 0.06 S, 0.06	{ 0.06 plates and rivets. 0.08 sectional material. 0.06
5	Branding	Each piece to be marked, with No. of cast, in case of cast test being agreed upon,	All plates and sectional material marked in 2 places with maker's name or trademark, place where made, and No. or marks by which they can be traced to cast.	
6	No. of Test Pieces	In case of a cast test being agreed upon: 3 pieces from each cast at most, however, 1 piece from every lot of 20 pieces or part thereof. In case of no cast test being agreed upon: 5 from each 100, at most, however, 1 piece from every 2 tons or part thereof.	One tensile test from every cast or 25 tons, whichever is least. One cold or one temper bend test from each plate, section, or bar, as rolled.	
7	Shape of Test Specimens	Area = $\frac{1}{2}$ - $\frac{3}{4}$ sq. in. (300-500 mm. ²) for tensile strength. For rounds of less than diameter: $\frac{3}{8}$ " (20 mm.): $l=10 \times$ diameter: For Bend Tests. Width $1\frac{1}{2}$ - $1\frac{3}{4}$ (30-50 mm.). Bar, rods, etc., in thickness according to mil. Outer skin not to be damaged.	For Plates and other Structural Material. For thickness > $\frac{3}{8}$ " (22.2 mm.) $\frac{3}{8}$ " - $\frac{7}{8}$ " (9.5-22.2 mm.) < $\frac{3}{8}$ " (9.5 mm.) $h = 1\frac{1}{2}$ " (38.1 mm.) 2" (50.8 mm.) 2 $\frac{1}{2}$ " (63.5 mm.) For Bars, Rods and Stays. Parallel for length of not less than 8 times diameter. With enlarged ends: parallel for length of not less than 9 times reduced diameter. Rivet bars tested full size as rolled. Bend test pieces to be not less than $1\frac{1}{4}$ in. (38.1 mm.) wide.	
8	Test Pieces	Cold, sheared edges, etc., removed by milling, planing, etc. Test piece to be annealed only when material from which it is taken is to be annealed.	Test pieces to be cut lengthwise or crosswise from plates, and lengthwise from Sectional Material and Bars. When material is annealed or otherwise treated, test pieces to be similarly treated. Straightening to be done cold. Sheared edges to be removed by milling, planing, etc.	

FOR STRUCTURAL STEEL.

U. S. A.			
Structural Steel for Bridges.		Structural Steel for Buildings.	
Open Hearth.		Open Hearth or Bessemer.	
Smooth, free from injurious seams, flaws, cracks, &c.			
Certificate re contents of:			
P, S, and Mn.		P.	
Highest values in percentage.			
Structural Steel.	Rivet Steel.	Structural Steel.	Rivet Steel.
P. Basic, - - - 0.04 Acid, - - - 0.06 S. - - - 0.05	0.04 0.04 0.04	Bessemer, - - - 0.1 Open hearth, - - - 0.06	0.06
Every finished piece of steel marked with blow No. and name of manufacturer, except that rivet and lattice steel and other small parts may be bundled with above marks on attached metal tag.		Every finished piece of steel stamped with blow No. except that small pieces may be shipped in bundles with metal tag attached.	
At least 1 tensile test and 1 bending test from each melt of steel as rolled.			
For tensile and bending tests for plates, shapes, and bars.			
Milled to form shown in sketch, or with both edges parallel; or they may be turned to a diameter of $\frac{3}{8}$ " (9.5 mm.) for a length of at least 9" (228.6 mm.), with enlarged ends.		The standard shape of the test specimen for sheared plates shall be as shown by the sketch. For other material the test specimen may be the same as for sheared plates, or it may be planed or turned parallel throughout its entire length, and, in all cases where possible, two opposite sides of the test specimen shall be the rolled surfaces.	
Rivet rounds tested as rolled.			
Special regulations for pins and rollers.			
When material is annealed or otherwise similarly treated, test pieces to be similarly treated.			

TABLE CVI.—SPECIFICATIONS

	Germany.		Great Britain.	
	Only for a thickness of $\frac{3}{8}$ "-1 $\frac{1}{2}$ " (7 to 28 mm.). [For other thicknesses as to be agreed upon.]		Tensile Strength, lbs./sq. in.	Minimum Elongation per cent.
9 Physical Tests, Properties	A. Tensile Tests.		Plates and sectional material	62,720-71,680 (44.1-50.5 kg./mm. ²)
			For material under $\frac{3}{8}$ inch (7.9 mm.) thick, bend tests only are required.	20
	Lengthwise	Tensile Strength, lbs./sq. in. 52,625-62,581 (37.44 kg./mm. ²)	Elongation per cent. ≥ 20	
	Crosswise	51,203-64,004 (36.45 kg./mm. ²)	≥ 17	
	Rivets and bolts	51,203-59,737 (36.42 kg./mm. ²)	≥ 22	
	B. Other Tests.		Rivet bars	58,240-67,200 (41.0-47.3 kg./mm. ²)
	1. Plate, Section or Bar.		Bend test unnecessary for rivet bars.	
	(a) Bend Tests.		Manufactured Rivets—Cold Bend Test. The shank shall be bent 180° until 2 parts of shank touch, without fracture on outside of bend. Rivet head will be flattened, white hot, until its diameter is $\frac{2}{3}$ times that of the shank, without cracking at edges.	
		Test piece lengthwise.	Test piece crosswise.	
	Heating, -	Light red hot.	Light red hot.	
Quenching, -	Water 28° C.	Water 28° C.		
Diameter of loops, -	Single thickness.	Double thickness.		
Fractures, -	Not permissible.	Surface fractures permissible.		
(b) Red Hot Breaking Tests.				
Got off by forging, -	Condition.	Punch.	Fracture	
Area: $1\frac{3}{8} \times 1\frac{1}{4}$ " (40 x 6 mm.)	Red hot.	$l = 3\frac{3}{8}$ " (80 mm.) $d_1 = 2\frac{1}{2}$ " (20 mm.) $d_2 = 1\frac{1}{2}$ " (30 mm.)	Not permissible.	
2. Rivet and Bolt Material.		Bend Tests—Cold and Hot.		
(a) Bend Tests.		When hot.		
Section, -	Bars, rods, &c.	Heating, -	Blood red.	
Heating, -	Light red hot.	Quenching, -	28° C. (80° F.)	
Quenching, -	Water at 28° C. (80° F.)	Bending, -	180°	
Diam. of loop, -	Half thickness.	Test pieces to withstand, without fracture, being doubled over until internal radius not greater than $1\frac{1}{2}$ times thickness of test piece, and the sides are parallel.		
Fracture, -	Not permissible.			
(b) Jumping Tests.				
Length before jumping = 2 x diameter.				
Heating, as by riveting.				
Length after jumping = $\frac{3}{4}$ x diameter.				
10 Rejection	For each test that fails, 2 further tests to be made from corresponding material, but should either of latter tests fail, material can be rejected.		Should test pieces first selected not fulfil requirements, 2 further tests may be made, but should either fail, material from which test pieces were cut shall be rejected.	
	Should test piece break outside of the middle third of gauged length, another test to be made, if elongation insufficient.		Further tests to be made before material from same cast is accepted. Should a tensile test piece break outside middle half of its gauge length, test may be discarded and another test made from same material.	
11 Permissible Variations			$\pm 2\frac{1}{2}$ % calculated weight.	

FOR STRUCTURAL STEEL.—Continued.



U. S. A.						
Structural Steel for Bridges.				Structural Steel for Buildings.		
	Tensile Strength, lbs./sq. in.	Elongation.		Tensile Strength, lbs./sq. in.	Elongation.	
		l	Minimum per cent.		l	Minimum per cent.
Structural Steel	60,000 (42.2 kg./mm. ²)	8 ins. (203.2)	1,500,000	Structural Steel	55,000 to 65,000 (38.7-45.7 kg./mm. ²)	8 ins. (203.2)
Rivet Steel	50,000 (35.2 kg./mm. ²)	8 ins. (203.2)	Tensile Strength	Rivet Steel	45,000 to 58,000 (33.7-40.3 kg./mm. ²)	8 ins. (203.2)
Character of fracture—Silky.						
Elongation—For material less than $\frac{3}{8}$ " (7.9 mm.) and more than $\frac{3}{4}$ " (19.1 mm.) in thickness, following modifications allowed.						
(a) For each $\frac{1}{16}$ " (1.6 mm.) in thickness below $\frac{3}{8}$ " (7.9 mm.), a deduction of 2½ per cent.						
(b) For each $\frac{1}{16}$ " (1.6 mm.) in thickness above $\frac{3}{4}$ " (19.1 mm.), a deduction of 1 per cent.						
Special regulations for pins.						
Bend Tests, by Pressure or Blows.						
Plates, shapes, and bars up to 1" (25.4 mm.) thick; cold bend, without fracture, to 180°.				Medium steel $\frac{3}{4}$ " (19.1 mm.) and less thick, test specimen shall be of same thickness as of material from which it is cut, but for material thicker than $\frac{3}{4}$ " (19.1 mm.), test piece may be $\frac{1}{2}$ " (12.7 mm.) thick. Width for both $1\frac{1}{2}$ " (38.1 mm.)		
Eye-bars and other steel 1" (25.4 mm.) thick and over, tested as rolled.				Test.—Medium steel shall bend cold 180° around a diameter equal to thickness of specimen tested, without fracture on outside bend.		
Cold Bend.	Diameter of Loop.	Without fracture on outside of bend.				
180°	Double thickness.					
Angles under Hammer.						
$\frac{1}{4}$ " (12.7 mm.) and less thick bend shut		} cold without fracture.				
$\frac{3}{8}$ " (19.1 mm.) and less thick open flat						
To be made only when required by inspector.						
Rivet Steel—Bend Tests.						
Diameter of loop, Flat.	Bend cold, 180° flat, without fracture on outside of bent portion.					
Break, - - - Gradual.						
Appearance, -	Fine, silky, uniform fracture.					
If the ultimate strength varies more than 4,000 lbs./sq. in. (2.8 kg./mm. ²) from that desired, a re-test to be made which, to be acceptable, shall be within 5,000 lbs. (3.5 kg./mm. ²) of desired ultimate.				Should test piece break outside of the middle third of gauged length, another test piece substituted therefor.		
Check analysis shall be made from finished material, if called for by purchaser; excess of 25 per cent. allowed.						
With regard to permissible variations from specified weight and dimensions, there exist special regulations for plates. For all other steel parts, the variation in cross-section and weight of the single pieces may amount to 2½ per cent. at the most.						

TABLE CVII.—SPECIFICATIONS FOR STEEL RAILS.

		Germany.		Great Britain.			U.S.A.	
		Rails and Tongue Rails.	Tramway Rails.	Flat Bottom Railway Rails.	Bull Head Railway Rails.	Tramway Rails.	Rails.	O.H. Rails.
1	Material - - -	Ingot Steel.		Steel.			Bessemer Steel.	Open Hearth Steel.
2	Process of Manufacture - - -	Optional, to be specified, however, in tender.		Optional, the purchaser, however, to approve.			Specified in Contract.	
3	Finish - - -	No cracks, fuse holes, injurious seams, burrs or defects of every kind. Square at ends.		Uniform section throughout, true to templates, perfectly sound and straight and free from splits, cracks, burrs and defects of any kind.			Straight in line and surface, smooth on head, sawed square at ends, no burrs, and the ends made clean. Not to vary throughout their entire length 5 inches (127 mm.) from a straight line in any direction, when delivered to the cold straightening presses.	
4	Chemical Analysis -	Not required.		Carbon and Phosphorus determinations of each cast. An analysis representing average of other elements in steel, to be given for each rolling up to 200 tons each. When rolling exceeds 200 tons an additional complete analysis to be made for each 200 tons or part thereof.	Carbon determinations of each cast. An analysis representing average of other elements in steel, to be given for each rolling up to 200 tons each. When rolling exceeds 200 tons an additional complete analysis to be made for each 200 tons or part thereof.	Carbon determinations of each cast. An analysis representing average of other elements in steel, to be given for each rolling up to 100 tons each. When rolling exceeds 100 tons an additional complete analysis to be made for each 100 tons or part thereof.	Daily carbon determinations for each blow, and a complete analysis every 24 hours, representing average of other elements in steel, for each day and night turn.	Determinations for each heat of all the elements specified.
5	Chemical Composition—per cent.							
	Carbon - - -	—	—	0.35-0.5	0.35-0.5	0.4-0.55	0.35-0.45, 0.45-0.55	0.46-0.59, 0.62-0.75
	Phosphorus - - -	—	—	0.07 not to exceed	0.075 not to exceed	0.08 not to exceed.	0.1 not to exceed	0.04 not to exceed
	Silicon - - -	—	—	0.1 " " "	0.1 " " "	0.1 " " "	0.2 " " "	0.20 " " "
	Manganese - - -	—	—	0.7-1.0	0.7-1.0	0.7-1.0	0.7-1.00, 0.84-1.14	0.60-0.90
	Sulphur - - -	—	—	0.07 not to exceed	0.08 not to exceed	0.08 not to exceed	—	—



6	Section - - -	According to template furnished by purchaser.	Each section to be accurately rolled to its respective template. 2 sets of templates (internal and external) supplied by manufacturer upon request of purchaser.			According to template furnished by purchaser.	
7	Branding - - -	Each rail to have manufacturers' mark and year, either when manufactured or when put into use, in raised letters, also number of blow. All on web.		Brand (see sketch) rolled on web, "B.S." number, process of manufacture, name, initials or other recognised mark and month and year of manufacture rolled in 3/4 inch (19.0 mm.) letters, and the number of the cast or blow stamped in 1/4 inch (12.7 mm.) block figures on end of each rail.		Same, without mention being made of month.	
8	Impact Test—Drop - - -	The rails have to stand the following tests: For rails weighing from 47 1/2 lbs./yd. (23.8 m./kg.) and over, 10,850 ft./lbs. (1,500 m./kg.) For rails weighing from 40 1/2 lbs./yd. (20 m./kg.) and down to 47 1/2 lbs./yd. (23.8 m./kg.), 7,238 ft./lbs. (1,000 m./kg.) For rails weighing from 32 1/2 lbs./yd. (16 m./kg.) down to 40 1/2 lbs./yd. (20 m./kg.), 5,424 ft./lbs. (750 m./kg.)	The first blow 10,850 ft./lbs. (1,500 m./kg.); the others 8,680 ft./lbs. (1,200 m./kg.)	8-30 ft. (2.44-9.14m.)	5-7 ft. (1.52-2.12m.) 1st blow. 10-20 ft. (3.05-6.10m.) 2nd blow.	15 ft. (4.57 m.) for rails less than 100 lbs./yd. (49.5 kg./m.) 18 ft. (5.48 m.) for rails of and exceeding 100 lbs./yd. (49.5 kg./m.)	Rails 70 lbs. per yard (34.7 kg./m.) and over to have a letter stamped on side of web to indicate the portion of the ingot from which the rail was rolled. 15-18 ft. (4.57-5.48 m.)
	Weight of Tup -			In 17 stages for rails of 20-100 lbs./yard (9.9-49.5 kg./m.)	In 9 stages for rails of 60-100 lbs./yard (30-50 kg./m.)		
	Length of Test Piece	4 ft. 3 1/4 in. (1.3 m.)	560-2240 lbs. (254-1016kg.) 5 ft. (1.52 m.)	2,240 lbs. (1,016 kg.) 5 ft. (1.52 m.)	At least 2,240 lbs. (1,016 kg.) 5 ft. (1.52 m.)	2,000 lbs. (906 kg.)	
	Centres of Bearings	3 ft. 3 ins. (1 m.)	{ For 20-65 lbs./yd. (9.9-32 kg./m.) 3 ft. (0.9 m.) For 70-100 lbs./yd. (34.7-49.5 kg./m.) 3 1/2 ft. (1.07 m.)	3 ft. 6 ins. (1.07 m.)	3 ft. 6 ins. (1.07 m.)	Anvil block of 20,000 lbs. (9,060 kg.) at least in standardised drop testing machine in general use to be described. 4-6 ft. (1.22-1.83 m.)	
						In 5 stages for rails of 50-100 lbs./yard. (24.8-99.5 kg./m.)	

TABLE CVII.—SPECIFICATIONS FOR STEEL RAILS.—Continued.



		Germany.		Great Britain.			U.S.A.	
		Rails and Tongue Rails.	Tramway Rails.	Flat Bottom Railway Rails.	Bull Head Railway Rails.	Tramway Rails.	Rails.	O.H. Rails.
8	Impact Test— <i>Continued.</i> Number of Blows - Required Deflection	Until required deflection.		1 blow.	2 blows.	1 blow.	1 blow.	
		At least 3 $\frac{1}{8}$ in. (100 mm.) for section of height 5 $\frac{1}{8}$ in. (134 mm.) and at least 5 $\frac{1}{2}$ in. (130 mm.) for tongue rails. For other sections including tongue rails, <i>vice versa</i> proportionately to the heights of sections.	At least 2 $\frac{3}{8}$ in. (60 mm.) with sections up to height of 5 $\frac{1}{8}$ in. (150 mm.); beyond that at least 1 $\frac{3}{8}$ in. (50 mm.)	—	From 1-1 $\frac{1}{8}$ " (25.4-33.3 mm.) to 1-1 $\frac{1}{4}$ " (22.2-30.1 mm.) From 3-3 $\frac{3}{4}$ " (76.2-95.2 mm.) to 3-4 $\frac{1}{4}$ " (76.2-108.0 mm.)	1st blow, according to weight of section. 2nd blow, ditto.	—	—
	Number of Tests -	1 test for each lot of 200 rails and portion thereof.		1 test from each cast, in addition one finished rail from every 200 offered.	1 test from each cast.	1 test from each 80 rails.	1 test from every cast.	
9	Tensile Tests— Dimensions of Test Piece	3 $\frac{1}{8}$ inch (25 mm.) diameter, 7 $\frac{1}{2}$ inches (200 mm.) length from centre of rail-head of pieces which have been subjected to impact test.		Diameter (14.3 mm.) 0.564 in. (20.3 mm.) 0.798 in. Area (161.3 mm. ²) $\frac{1}{4}$ sq. in. Gauge length (50.8 mm.) 2". Parallel for a length of not less than (57.2 mm.) 2 $\frac{1}{2}$ ins. (63.75-6 kg./mm. ²) 40-48 t. p. sq. in.	(322.6 mm. ²) $\frac{1}{2}$ sq. in. (76.2 mm.) 3 ins. (85.7 mm.) 3 $\frac{3}{8}$ ins. (59.9-70.9 kg./mm. ²) 40-48 t. p. sq. in.	(50.8 mm.) 2 in. long. (322.6 mm. ²) $\frac{1}{2}$ sq. in. approximate sectional area.	Not called for.	
	Tensile Strength -	min. 39 t. p. sq. in. (60 kg./mm. ²)	min. 46 t. p. sq. in. (70 kg./mm. ²)	(63-75.6 kg./mm. ²) 40-48 t. p. sq. in.	(59.9-70.9 kg./mm. ²) 40-48 t. p. sq. in.	(63 kg./mm. ²) at least 40 t./sq. in.		
	Elongation -	To be given.		15 per cent. (min.)	15 per cent. (min.)	12 per cent.		
	Number of Tests -	1 test for each lot of 200 rails and portion thereof.		1 test for each 100 tons rails.	1 test for each 100 tons rails.	1 test for each 100 tons rails.		

10	Rejection	Should the test piece fail to comply with the impact and tensile tests, a second and eventually a third rail is taken from the same cast. Should one of these fail to fulfil the specified requirements all the rails belonging to such cast may be rejected. The whole delivery can be rejected if on testing no settled conviction is arrived at of the faultless condition of the rails, or, if after the rails are accepted, defects or defaults, arise showing that the rails have not been made in accordance with the specified condition.		Should the length cut from the selected rail fail to comply with the drop test specified, two other rails from same cast will be selected, both of which must comply with specified requirements or cast will be rejected. Should the test piece fail to comply with the tensile test, two other rails may be taken from the same cast, both of which must comply with the specified requirement or cast will be rejected. The engineer may then take similar test pieces from two other rails out of the same 100 tons and should either fail whole 100 tons may be rejected.	If the test piece fractures under drop test, all rails from that cast may be rejected, unless it is shown from similar trial on two further pieces of rail that first piece was not fairly representative of quality of steel. Should test piece fail to comply with tensile test another rail may be taken from the same cast, and it must fulfil specified requirements or cast will be rejected.	If any rail breaks under drop test, two additional tests will be made from same cast, and if either of latter tests fail all rails of such blow will be rejected.
11	Permissible Variations, (a) Dimensions— In Length	Up to 29 $\frac{1}{2}$ ft. (9 m.) $\pm \frac{1}{8}$ in. (2 mm.) Above 29 $\frac{1}{2}$ ft. (9 m.) $\pm \frac{1}{4}$ in. (3 mm.) No variation in the case of tongue rails. 5 per cent. of contract may be shorter than specified.	Up to 39 ft. 4 in. (12 m.) $\pm \frac{1}{8}$ in. (3 mm.)	Normal length, 9-144, 10-973, 13-716 or 18-288 m. (30, 36, 45 or 60 ft.) $\pm \frac{1}{8}$ in. (4.3 mm.) specified length. 7 $\frac{1}{2}$ per cent. of contract may be shorter than specified.	Normal length, 10-668, 13-716 or 18-288 m. (35, 45 or 60 ft.) 2 $\frac{1}{2}$ -5 per cent. shorter as specified. $\pm \frac{1}{8}$ in. (6.3 mm.) from the lengths specified.	Normal length, 30 and 33 feet (9.144 and 10.058 m.) 10 per cent. of order will be accepted in length varying by even feet to 24 feet (7.312 m.) $\pm \frac{1}{8}$ in. (6.35 mm.) specified length.
	In Straightness	Warped rails not accepted.	Up to $\frac{1}{8}$ in. (3 mm.) for 29 $\frac{1}{2}$ ft. (9 m.) vertically and horizontally. Those warped rails which are more than $\pm \frac{1}{8}$ in. (± 1.5 mm.) from the straight will not be accepted.			Square at ends not over $\frac{1}{8}$ in. (0.8 mm.) variation. Must be straight in line and surface.

TABLE CVII.—SPECIFICATIONS FOR STEEL RAILS.—Continued.

	Germany.		Great Britain.			U.S.A.	
	Rails and Tongue Rails.	Tramway Rails.	Flat Bottom Railway Rails.	Bull Head Railway Rails.	Tramway Rails.	Rails.	O.H. Rails.
11 Permissible Variations—Continued In position and size of holes	$\pm \frac{1}{16}$ in. (1 mm.)	$\pm \frac{1}{16}$ in. (1 mm.)	$\pm \frac{1}{16}$ in. (0.8 mm.)	$\pm \frac{1}{16}$ in. (0.8 mm.)	For fish bolts $\frac{1}{16}$ in. (1.6 mm.)	Must accurately conform to drawing.	
In width of head	$\pm \frac{1}{16}$ in. (0.5 mm.)	$\pm \frac{1}{16}$ in. (1 mm.)				$\frac{1}{16}$ in. (1.6 mm.)	
In thickness of web	$\pm \frac{1}{16}$ in. (0.5 mm.)	$\pm \frac{1}{16}$ in. (1 mm.)				$\frac{1}{16}$ in. (1.6 mm.)	
In width of bottom	$\pm \frac{1}{16}$ in. (1 mm.)	$\pm \frac{1}{16}$ in. (2 mm.)				$\frac{1}{16}$ in. (1.6 mm.)	
In height	$\pm \frac{1}{16}$ in. (0.5 mm.)	$\pm \frac{1}{16}$ in. (1 mm.)			$\pm \frac{1}{16}$ in. (0.8 mm.) Distance between fishing angles $\pm \frac{1}{16}$ in. (0.4 mm.)	- $\frac{1}{16}$ in. to + $\frac{1}{16}$ in. (0.4 to + 0.8 mm.)	
(b) Weight	+ 3 per cent. to - 2 per cent. Additional weight up to 1 per cent. will be paid for, otherwise the actual weight. Normal weight being the actual weight of 50 faultlessly rolled rails.	+ 4 per cent. to - 3 per cent. Additional weight up to 1 per cent. will be paid for, otherwise the actual weight. Normal weight being the actual weight of 50 faultlessly rolled rails.	$\pm \frac{1}{2}$ per cent. calculated weight, but actual weight only paid for.		Max. 1 lb. per yard (0.5 kg./m.)	$\pm \frac{1}{2}$ per cent. accepted and paid for according to actual weight. The finishing temperature in rolling is controlled by the amount of shrinkage, not more than $6\frac{1}{2}$ inches (163.5 mm.) allowed per 33 feet (10.058 m.) 75-lb. rail (37.2 kg./m.), with $\frac{1}{16}$ (1.6 mm.) increase per each increase of 5 lbs. (2.5 kg.) in the weight of the section.	

TABLE CVIII.—SPECIFICATIONS FOR FISH PLATES.

	Germany.		Great Britain.		U.S.A.	
	Fish Plates for Railway and Tramway Rails.		Fish Plates for Tramway Rails.		Splice Bars.	
1 Material	Ingot Steel.		Steel.		Bessemer or Open Hearth.	
2 Process of Manufacture	Optional, to be specified, however, in tenders.		Optional, but the steel shall be in all respects similar to that used in the manufacture of the rails and to be approved by purchaser.		—	
3 Finish	According to template, smoothly and cleanly rolled. No cracks, fuse holes, defective edges or other defects. Perfectly straight.		Conforming to template, quite straight and smooth on all bearing surfaces, free from twists, cracks, blisters or other defects, and shall have all fins and burrs carefully removed.		Smoothly rolled and true to template. Sheared accurately to length and free from fins or cracks and shall perfectly fit the rails. Punching and notching shall accurately conform in every respect to drawings and dimensions furnished. Phosphorus not over 0.10.	
4 Chemical Analysis	—		According to the requirements specified for Rails.		The name of the maker and year of manufacture shall be rolled in raised letters on the side of the splice bar.	
5 Branding	Manufacturer's mark, year of delivery, shown by last 2 figures, number mentioned on drawing.		 Brand, "B.S.," Number, Manufacturer's Name (initials) and year of manufacture, rolled in raised letters of at least $\frac{1}{16}$ in. (12.7 mm.) in size.		55,000-65,000 lbs. per sq. in. (38.67-45.70 kg./mm. ²). Elongation in 8 ins. (203.2 mm.) not less than 25 per cent. Minimum yield point, 0.5 tensile strength.	
6 Physical Tests—	Ingot Steel of 24 $\frac{1}{2}$ to 32 t./sq. in. (38-50 kg./mm. ²) Ingot Steel of 32 to 39 t./sq. in. (50-60 kg./mm. ²)		At least 40 t./sq. in. (63.0 kg./mm. ²). In accordance with the requirements specified for Tramway Rails.		180° flat 	
Span	(16 $\frac{1}{2}$ in.) 420 mm.		Capable of being bent cold, and before being punched, to a right angle round a bar 4 ins. (101.6 mm.) in diameter, without showing fracture on outside.		A full sized bar first flattened and then bent 180° flat.	
Permanent Deflection	min. ($\frac{1}{4}$ in.) 6 mm.		—		—	
Wedging Test— (Aufkeilprobe)	At the front opening of the clinch (Klinke) at least $\frac{1}{16}$ in (2 mm.) with a wedge inclined at 1 : 20.		—		—	
Number of Tests	1 test for each 500 Fish Plates.		(Same as for Tramway Rails) 1 test for each 100 ton.		1 test from each blow or melt.	
7 Rejection of Fish Plates	If 2 from each 100 of a part delivery submitted for acceptance fail to comply with specified requirements the whole of such part delivery may be rejected.		If the test piece fails to comply with the specifications, another test piece of same cast will be tested.		Each blow or melt accepted or rejected on results of tests from that blow or melt.	
8 Permissible Variations.						
(a) Dimensions—						
In length	$\pm \frac{1}{16}$ in. (3 mm.)		—		Must be rolled true to template.	
In position and size of holes	$\pm \frac{1}{16}$ in. (0.5 mm.)		$\pm \frac{1}{16}$ in. (1.6 mm.)		—	
In bearing face	+ $\frac{1}{16}$ in. (0.25 mm.)		—		—	
In thickness	$\pm \frac{1}{16}$ in. (0.5 mm.)		—		—	
In other dimensions	$\pm \frac{1}{16}$ in. (1 mm.)		—		—	
In distance of clinches (Im Abstand der Einklinkungen)	$\pm \frac{1}{16}$ in. (2 mm.)		—		—	
In size of clinches	$\pm \frac{1}{16}$ in. (1 mm.)		—		—	
(b) Weight	+ 3 per cent. to - 2 per cent. Additional weight is paid for up to 1 per cent.		Actual weight is paid for.		Actual weight is paid for.	