TB

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Rails for high speed railway

高速铁路用钢轨

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Rails for high speed railway

1 Scope

This Standard specifies the type dimensions and tolerances, technical requirements, test methods, inspection rules, marking and quality certificate, quality assurance, etc. of the rails.

This Standard applies to 60 kg/m hot-rolled rails for high speed railway operating at speeds of 200 km/h and above. Rails for railway operating at speeds greater than 160 km/h and less than 200 km/h may refer to it for implementation.

2 Normative references

The following documents are indispensable for the application of this document. For the dated references, only the editions with the dates indicated are applicable to this document. For the undated references, the latest edition (including all the amendments) are applicable to this document.

GB/T 223.14 Methods for Chemical Analysis of Iron, Steel and Alloy - The N-Benzoy-N-Phenylhydroxylamine Extraction Photometric Method for the Determination of Vanadium Content

GB/T 223.60 Methods for chemical analysis of iron, steel and alloy - The perchloric acid dehydration gravimetric method for the determination of silicon content

GB/T 223.62 Methods for chemical analysis of iron, steel and alloy - The butyl acetate extraction photometric method for the determination of phosphorus content

GB/T 223.63 Methods for chemical analysis of iron, steel and alloy - The sodium (potassium) periodate photometric method for the determination of manganese content

GB/T 223.68 Methods for Chemical Analysis of Iron, Steel and Alloy - The Potassium Iodate Titration Method after Combustion in the Pipe Furnace for the Determination of Sulfur Content

GB/T 223.71 Methods for Chemical Analysis of Iron, Steel and Alloy - The Gravimetric Method after Combustion in the Pipe Furnace for the

Determination of Carbon Content

GB/T 223.82 Steel and iron - Determination of hydrogen content - Thermal conductivity/infrared method after fusion under inert gas

GB/T 226 Test method for macrostructure and defect of steel by etching

GB/T 228 Metallic materials - Tensile testing at ambient temperature

GB/T 231.1 Metallic materials - Brinell hardness test - Part 1: Test method

GB/T 3075 Metallic materials - Fatigue testing - Axial-force-controlled method

GB/T 4161 Metallic materials - Determination of plane-strain fracture toughness

GB/T 4336 Carbon and low-alloy steel - Determination of multi-element contents - Spark discharge atomic emission spectrometric method (routine method)

GB/T 6398 Metallic materials - Fatigue testing - Fatigue crack growth method

GB/T 10561-2005 Steel - Determination of Content of Nonmetallic Inclusions - Micrographic Method Using Standards Diagrams

GB/T 11261 Steel and Iron - Determination of oxygen content - The pulse heating inert gas fusion-infra-red absorption method

GB/T 13298 Inspection methods of microstructure for metals

GB/T 19001 Quality management systems - Requirements

GB/T 20066 Steel and Iron - Sampling and Preparation of Samples for the Determination of Chemical Composition

GB/T 20124 Steel and iron - Determination of nitrogen content - Thermal conductimetric method after fusion in a current of inert gas

YB/T 081 Rule for rounding off of numerical values and judgement of testing values for technical standards of metallurgy

3 Terms and definitions

The following terms and definitions apply to this document.

3.1 Heat

All slabs cast from a furnace of molten steel; but excluding the first slab cast from the next furnace of molten steel entering into tundish casting.

3.2 Sequence

Continuous casting of the same designation by molten steel of different heats in tundish.

3.3 Transition area

The part cast by a mixture of two furnaces of molten steel.

4 Grading and selection

4.1 Grading

The nonmetallic inclusions in the steel are divided into two grades, A and B.

4.2 Selection

This Standard specifies two steel designations of U71MnG and U75VG. High speed railways above 250 km/h and high speed passenger railways of 200 km/h ~ 250 km/h shall select U71MnG rails. High speed passenger and freight mixed railways of 200 km/h ~ 250 km/h shall select U75VG rails.

For nonmetallic inclusions of rails for high speed railway above 250 km/h, it shall adopt Grade A. For nonmetallic inclusions of rails for high speed railway of 200 km/h ~ 250 km/h, it shall adopt Grade B.

5 Information required for ordering

When the user is ordering, it shall provide the following basic information:

a) Product name;

b) Product standard number;

c) Steel designation;

d) Rail type and applicable speed range (or grade of nonmetallic inclusions);

e) No-hole or hole rail (number of holes, one end drilled or both ends drilled);

f) Length, quantity, and off-size rate;

g) Other requirements.

7.8 Macrostructure

The macrostructure of the etched test piece of cross-section of rail shall comply with the provisions of Appendix B.

7.9 Drop hammer

The rail shall be subjected to a drop hammer test. The sample, after being hammered once, shall not be broken. Deflection values shall be given in the quality certificate for reference.

7.10 Surface quality

7.10.1 There shall be no cracks on the rail surface.

7.10.2 All the protruding parts (except the hot-rolling identification), which affect the installation of fish plate, of rail running surface (i.e. rail crown), lower surface of rail flange, and within 1 m from the rail end shall be ground.

7.10.3 The maximum allowable depth of rail wear, thermal scratches, longitudinal lines, folds, scale indentation, rolling marks, etc. formed in the hot state:

a) Rail running surface: 0.35 mm;

b) Other parts of rail: 0.5 mm.

In any part of the length of rail, longitudinal fore-plate scratches are only allowed to have a maximum of 2. The depth shall not exceed the regulations. But on the rail running surface, only 1 is allowed. Fore-plate scratches which occur repeatedly along the same axis may be recognized as 1.

It is allowed that the maximum width of fore-plate scratch is 4 mm; the ratio of width to depth is greater than or equal to 3:1.

The periodic hot-rolling marks produced by the rolls may be recognized as 1 and can be ground.

7.10.4 The maximum allowable depth of defects such as longitudinal and lateral scratches of the rail formed in the cold state:

a) Rail running surface, lower surface of rail flange: 0.3 mm (The lower surface of rail flange shall not have lateral scratches);

b) Other parts of rail: 0.5 mm.

7.10.5 There shall be no damage of martensite or white phase structure on the

rail surface; if any, it shall be eliminated.

7.10.6 Surface defect detection and grinding: The depth of surface defect shall be detected by a depth detector. When the depth cannot be measured, it shall be confirmed by test. When grinding surface defects, the contour of grinding surface shall be smooth; it shall ensure that the microstructure of the rail after grinding is not affected.

Maximum allowable grinding depth:

a) Rail running surface: 0.35 mm;

b) Other parts of rail: 0.5 mm.

In 10 m length of the rail, there shall be no more than 3 surface defects. 1 grinding may be done every 10 m. The number of grinding points for periodic hot-rolling marks in the rail crown portion shall not exceed 3 per 50 m. The geometric dimension tolerances and straightness of the rail after grinding shall comply with the requirements of Table 1.

Within 1 m from the rail end, the rail running surface and the rail head side, except for the protruding part, shall not be ground.

If the section size and straightness of the rail are unqualified, except for the protruding part, it shall not adopt the grinding method for treatment.

When thermal and cold injuries of the rail meet the requirements of 7.10.3 and (or) 7.10.4, the grinding may be omitted.

7.10.7 It shall, along the entire length of the rail, automatically detect the bottom surface of the rail. The equipment used shall be capable of detecting the artificial defect of the size shown in Table 7. The tolerance of the size of artificial defect is ±0.1 mm. When using automatic rail flange detection technique to detect, a blind zone of up to 5 mm wide is allowed on each side of the edge of the rail flange. Every 8 h, USE test rails with artificial defects to calibrate once. When the automatic detection equipment cannot work properly, it shall use an artificial mirror to check.

Table 7 -- Size of artificial defect (in millimeters)

Defect depth	Defect length	Defect width
1. 0	20	0. 5
1. 5	10	0. 5

7.11 Ultrasonic flaw detection

The full length of the rail shall be continuously inspected by ultrasonic flaw

Table 10 (continued)

No.	Inspection items	Inspection frequency	Sampling locations	Test methods
10	Nonmetallic inclusions	Once per lot	CUT longitudinally at the rail head 10 mm ~ 15 mm from the top surface of rail. The inspection surface shall be parallel to the top surface of the rail and centered. The area shall not be less than 200 mm^2	Method A of GB/T 10561-2005
11	Macrostructure	Once per furnace	TAKE randomly 1 sample	GB/T 226
12	Drop hammer	Once per lot	TAKE randomly 1 sample	See 8.6
13	Ultrasonic flaw detection	Piece by piece	Full length	See 8.7
14	Dimensions	Piece by piece	Full length anywhere	Appendix E sample plate or laser automatic detection equipment
15	Straightness and distortion	Piece by piece	See 6.4	Rail production plants shall use online laser automatic detection equipment to detect the full-length straightness of the rail. The straightness of rail end shall be measured using a 1 m, 2 m ruler and feeler gauge. The distortion of rail end shall be measured using a twisted ruler
16	Surface quality	Piece by piece	Full-length all surfaces	Naked eye, rail flange automatic detection
17	Residual stress of rail flange	Once every 2 years	CUT at a location at least 3 m from the rail end	See 8.8
18	Fracture toughness	Once every 5 years	CUT at a location at least 3 m from the rail end according to Figure D1	See 8.9
19	Fatigue crack growth rate	Once every 5 years	CUT at a location at least 3 m from the rail end according to Figure 10	See 8.10
20	Fatigue	Once every 5 years	CUT at a location at least 3 m from the rail end according to Figure 11	See 8.11

8.8 Residual stress of rail flange

The determination of the residual stress of rail flange is carried out in accordance with the method specified in Appendix C.

8.9 Fracture toughness

The test of fracture toughness is carried out in accordance with the method specified in Appendix D.

8.10 Fatigue crack growth rate

USE a three-point bending and one-sided notched sample to carry out the test of fatigue crack growth rate. The sampling location and sample size are shown in Figure 10. TAKE at least 3 samples on each sample rail and test under the following conditions:

a) Test temperature: 15 °C ~ 25 °C;

b) Minimum cyclic loading/maximum cyclic loading R=0.5;

c) The three-point bending sample has a loading span of 4W (see Figure 10);

d) Cyclic loading frequency: 15 Hz ~ 40 Hz;

e) Test environment: Atmospheric environment in the test room.

For other relevant regulations, see GB/T 6398.

9 Inspection rules

9.1 Supervision

The purchaser has the right to supervise the various processes and various inspections of the rail production and has the right to check these inspection results.

9.2 Type inspection

9.2.1 Under the following conditions, the supplier shall perform type inspection:

a) Before new varieties are laid on the road;

b) Major changes have occurred in production processes and production equipment, etc.;

c) Every 5 years in normal production;

d) Production is suspended for more than 6 months.

9.2.2 All inspections shall be performed in a qualified laboratory.

9.2.3 The supplier shall provide the purchaser with all inspection records, calibrations, and calculated values on which the final result of type inspection is based.

9.2.4 Type inspection includes all items in Table 10. Samples for No. 12 ~ No. 20 inspections shall be cut from straightened rails. No mechanical or thermal treatment of these samples is made. The samples used for fracture toughness, fatigue crack growth rate, and fatigue test shall be cut from 3 sample rails. The sample rails shall be taken from different heats and different continuous casting strand numbers. For the residual stress test, it shall select 6 sample rails. The sampling locations and test methods for the inspections are shown in Table 10.

9.3 Exit-factory inspection

9.3.1 Lot grouping rule: Each lot consists of rails of the same designation and the same model which are rolled from billets continuously cast from several furnaces of molten steel.

9.3.2 The exit-factory inspection of the rails is carried out by the supplier's quality inspection department. If necessary, the purchaser has the right to conduct sampling inspection. The specific items shall be separately agreed upon by the supplier and the purchaser at the time of ordering.

9.4.4 Macrostructure

9.4.4.1 The white point of rails is not allowed to be re-inspected .

9.4.4.2 When the initial inspection of macrostructure does not meet the requirements of this Standard, on both sides of the front and back of the sampling location for the initial inspection of the same strand respectively, one sample shall be taken for re-inspection. At least one of the two re-inspection samples is taken from the rail of the same slab as the initial inspection sample. It shall not accept the rail between the two re-inspection samples. If the re-inspection results of the two re-inspection samples meet the requirements, the remaining rails of this lot can be accepted. If there is a re-inspection sample which is unqualified, sampling may be continued for inspection again until qualified.

9.4.4.3 When it is difficult to recognize macrostructure defects, at higher magnifications, further inspection may be performed.

9.4.5 Drop hammer

When the drop hammer inspection results do not meet the requirements of this Standard, one sample shall be taken from all other heats of the same sequence for inspection. For the furnace where the initial inspection is not qualified, on both sides of the front and back of the sampling location for the initial inspection of the same strand respectively, one sample shall be taken for re-inspection. At least one of the two re-inspection samples is taken from the rail of the same slab as the initial inspection sample. It shall not accept the rail between the two re-inspection samples. If the results of the two re-inspection samples meet the requirements, the remaining rails of this furnace can be accepted. If there is still a re-inspection sample which is unqualified, sampling may be continued for inspection again until qualified.

9.4.6 Decarburization layer

When the initial inspection result is unsatisfactory, it shall sample from two adjacent rails of the same lot for re-inspection. If the re-inspection results of the two re-inspection samples meet the requirements, the remaining rails of this lot can be accepted. If the re-inspection sample is unqualified, sampling may be continued on the adjacent-side rails for inspection again until qualified. It shall not accept the rail between the two re-inspection samples.

9.5 Rounding off of numerical values

Except as otherwise provided in the contract or the order, when it is necessary to assess whether the test result meets the specified value, the test result given shall be rounded off to the digit position indicated by the specified value

standard number. The method for rounding off shall be in accordance with YB/T 081.

10 Marking and quality certificate

10.1 Marking

10.1.1 On the rail waist of one side of each rail, at least within every 4 m spacing, it shall roll the following clear and raised marks. The character has a height of 20 mm ~ 28 mm and a bulge of 0.5 mm ~ 1.5 mm:

a) Marking of production plant;

b) Rail type;

c) Steel designation;

d) Manufacturing year (two digits at the end of rolling year), month.

10.1.2 On the waist of each rail, no less than 0.6 m from the rail end and no more than 15 m of the spacing, USE a hot stamping machine (No cold stamping is allowed) to stamp the following clear marks in order. The stamped characters shall have a straight or circular arc surface. The character has a height of 10 mm ~ 16 mm, a depth of 0.5 mm ~ 1.5 mm, a width of 1 mm ~ 1.5 mm. The sides shall be inclined. Letters and numbers shall be at an angle of 10° to the vertical direction and have arc corners:

a) Heat;

b) Continuous casting strand number;

c) Continuously cast slab number;

d) Rail sequence number.

10.1.3 If the hot-printed mark is missing or has changed, it shall re-hot-print or stencil on the rail waist.

10.1.4 After the rail is finished, a label is attached to the head of one end face of the rail. The contents of the label shall include the rail standard number, applicable speed range, model, steel designation, heat, length, etc. The label barcode shall contain complete information on the hot stamping mark of the rail.

10.1.5 When there is no mark, or the mark is unclear and cannot be recognized, it is not allowed to leave the factory.

When $[V_i^* - \Sigma V_{1pi}] \leqslant 0.25[V_i^* - (\Sigma V_{pi} + \Sigma V_{1pi})]$, the test results are valid.

D.5.5 The linearity criterion does not apply to the type IV load-crack opening curve.

D.5.6 For all load-crack opening curves, it shall carry out the valid verification of K_Q value; that is, the sample thickness (B) and the crack length (a) shall be equal to or greater than $2.5(K_Q/R_{P0.2})^2$, where $R_{P0.2}$ is the yield strength at a fracture test temperature of - 20 °C.

D.6 Test report

D.6.1 When calculating test results and indicating the conditions specified during the test, it shall record all measured values required.

D.6.2 It shall report all test results, including K_{IC}, or K_Q^*, or K_Q. Where K_Q^* is a K_Q value which simply cannot satisfy one or more of the following conditions:

a) $P_{max}/P_Q > 1.1$;

b) A criterion of more than $2.5(K_Q/R_{P0.2})^2$;

c) Does not meet the relationship between crack opening displacement and load.

D.6.3 The average and standard deviation of K_{IC} and K_Q^* shall be recorded as specified in Table D.1.

Table D.1 -- Record of average and standard deviation of K_{IC} and K_Q^*

Steel designation of rail	$R_{P0.2}$ (- 20 °C) MPa	K_{IC} average MPa • $m^{1/2}$	Number of measurements for K_{IC}	Standard deviation of sample MPa • $m^{1/2}$	K_Q average MPa • $m^{1/2}$	Number of measurements for K_Q	Standard deviation of sample MPa • $m^{1/2}$

D.6.4 The average of at least 5 K_{IC} shall be used for acceptance. When 5 K_{IC} values are not available, the K_{IC} average for acceptance shall include K_Q^*. The number of tests in these results shall be no less than 10. All K_{IC} or K_Q^* values shall meet the requirements of Table 8.

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