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**Specification for dynamic performance assessment
and testing verification of rolling stock**

机车车辆动力学性能评定及试验鉴定规范

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Specification for dynamic performance assessment and testing verification of rolling stock

1 Scope

This standard specifies the method and assessment index, for the dynamic performance test and verification of standard gauge rolling stocks along the line.

This standard applies to the dynamic performance assessment and test verification of standard gauge rolling stocks along the line. For the test verification of dynamic performance of urban rail vehicles, industrial and mining electric power, diesel locomotives, it may refer to this standard.

This standard does not apply to test verification of the dynamic performance of railway machinery, such as the standard gauge railway special vehicles (long-large freight trains and rail vehicles with and without power), construction machinery (bridge erecting machines, track laying machines, track cranes, etc.), road maintenance machinery (screening machines, tamping machines, etc.).

2 Normative references

The following documents are essential to the application of this document. For the dated documents, only the versions with the dates indicated are applicable to this document; for the undated documents, only the latest version (including all the amendments) is applicable to this standard.

TB/T 3332-2013 Railway application - Method for the determination of wheel track equivalent conical degree

TB/T 3355-2014 Dynamic testing and assessment of geometric state of track

UIC 513:1994 Guidelines for evaluating passenger comfort in relation in railway vehicle

3 Terms and definitions

The following terms and definitions apply to this document.

3.1

Maximum operating speed

The maximum speed, to which the rolling stock can adapt to, in case of long-term continuous operation.

Note: The maximum operating speed is expressed in kilometers per hour (km/h).

3.2

Operating speed

The operating speed, which is comprehensively determined based on the transportation organization, routes, signals, rolling stocks.

Note: The operating speed is expressed in kilometers per hour (km/h).

3.3

Permissible cant deficiency

The maximum unbalanced superelevation allowed, when the rolling stock passes through a curve.

Note: The permissible cant deficiency is expressed in millimeters (mm).

3.4

Wheel-rail interaction force

The interaction force between the wheel and the rail.

Note: Wheel-rail interaction force is divided into wheel-rail vertical force P and wheel-rail lateral force Q , which are measured on each wheel. Wheel-rail interaction force is expressed in kilo-Newtons (kN).

3.5

Wheelset lateral force

The vector sum of the lateral forces of left and right wheel-rails.

Note: The lateral force of the axle is expressed in kilo-Newtons (kN).

3.6

Vibration acceleration

Linear acceleration, which is measured on parts, such as axle box, bogie, vehicle body.

Note: Vibration acceleration is expressed in meters per second (m/s^2).

radius curve, small radius curve.

- d) The actual status of rolling stock, such as unladen status, empty vehicle, heavy vehicle, etc.

6.4 The surface of the rail should be in a dry state. The state of the rail, climatic conditions, test time shall all be stated in the test report.

7 Test conditions

7.1 General rules

The test operating conditions shall consider factors, such as route grade, test speed, cant deficiency, curve radius, marshalling, running direction.

7.2 Test segments and sampling requirements

7.2.1 Classification of test segments

The test segment is divided into straight line, large radius curve, small radius curve, straight through turnout, lateral through turnout.

7.2.2 Straight-line segment

7.2.2.1 The maximum test speed $V_{\max}$ is 1.1 times V_{mopr} OR $V_{\text{mopr}} + 10$ km/h, whichever is larger. The test shall be divided into several speed levels, at the maximum test speed. The recommended speed level increment is 10 km/h or 20 km/h. The tolerance of speed control is ± 5 km/h.

7.2.2.2 The quantity of sampling segments, N , at each speed level, is ≥ 25 .

7.2.2.3 The sampling length of each segment: if $V_{\text{mopr}} \leq 220$ km/h, then $l = 250$ m; if $V_{\text{mopr}} > 220$ km/h, then $l = 500$ m. The tolerance of sampling length of each segment is 10%.

7.2.3 Large radius curve segment

7.2.3.1 The curve radius of the large radius curve is selected, according to different operating conditions, vehicle types, speed levels, actual working conditions of common routes, with reference to Table 2 and Table 3.

7.2.5.1 The maximum test speed $v_{\max}$ is 1.1 times v_{opr} , which shall not be lower than v_{opr} under difficult conditions. The test shall be divided into a number of speed levels, at the maximum test speed; the speed level increments are 10 km/h or 20 km/h. The tolerance of speed control is ± 5 km/h.

7.2.5.2 Each turnout area, through which it passes straightly, is regarded as a sampling segment. The number of sampling segments, N , at each speed level, is ≥ 10 .

7.2.6 Lateral through turnouts

7.2.6.1 The maximum test speed $v_{\max}$ is 1.1 times v_{opr} , which shall not be lower than v_{opr} under difficult conditions. The tolerance of speed control is ± 2 km/h.

7.2.6.2 The turnout passing laterally is the No.12 turnout or the No.9 turnout.

7.2.6.3 Each turnout area, through which it passes laterally, shall be regarded as a sampling segment. The number of sampling segments, N , is ≥ 10 .

7.3 Rolling stocks under test

7.3.1 Mechanical characteristics

7.3.1.1 During the verification test, the manufacturer shall provide the relevant characteristic parameters of the rolling stock under test; confirm that its condition is normal AND meets the specified requirements.

7.3.1.2 For freight train bogies, which have friction damping devices, it shall measure the relative friction coefficient. The method is as shown in Appendix A. The measured results shall be recorded in the test report.

7.3.2 Load status

7.3.2.1 The rolling stock test shall be carried out in the unladen state.

7.3.2.2 The test of passenger trains and EMUs shall be carried out in the unladen state.

7.3.2.3 The test of freight train shall be carried out under empty and marked load conditions, respectively.

7.3.3 Tread profile of wheel rim

7.3.3.1 There shall be no abnormalities, such as scratches or peeling, on the tread of the wheel rim.

7.3.3.2 It shall record the rim tread profile of the tested rolling stock. Confirm that its state is normal. Record it in the test report. The wheel track equivalent

conical degree is calculated in accordance with the provisions of TB/T 3332-2013.

7.3.4 Air spring

If it is an air spring suspension vehicle, for safety reasons, it should supplement the operation test of the air spring after losing air, under the same conditions as specified in 7.2. The test speed is gradually increased; the maximum test speed is controlled within the allowable range of the operational stability index.

7.4 Marshalling and running direction

7.4.1 General rules

For the marshalling and running direction of the tested rolling stock, it shall consider the operating conditions that may be encountered, in the operation of the tested rolling stock. In order to simplify the test, only the most unfavorable operating conditions proved by the test experience can be used for the test, for the purpose of simplifying the test.

The test rolling stock runs in a special train mode.

7.4.2 Position in the rolling stock

7.4.2.1 For passenger trains and freight trains, they are generally hung at the end of the tested rolling stock. If multiple vehicles are tested at the same time, the marshalling position shall be clearly indicated in the test report.

7.4.2.2 For rolling stocks, the test is carried out in the traction state.

7.4.2.3 For EMUs or trains whose marshalling cannot be changed, it shall describe the type of tested vehicle AND its position in the rolling stock, in the report.

7.4.3 Running direction

The test of passenger trains and EMUs shall be carried out in both forward and reverse directions.

7.5 Test system

See Appendix B for the requirements for the test system.

8 Measurement parameters

8.1 Wheel-rail interaction force

8.3 Displacement

According to the characteristics of the test bogie, select installing the vertical, lateral or longitudinal displacement sensors, on the relevant locations of the primary suspension and secondary suspension, to measure the displacement of the spring (the vertical displacement of the primary spring S_{jz} , the lateral displacement of the secondary spring S_{ty} , the vertical displacement of secondary spring S_{tz} , etc.).

9 Assessment Index

9.1 Operational stability

9.1.1 Overview

Operational stability is evaluated, by the use of index, such as derailment coefficient, wheel load reduction rate, wheelset lateral force, lateral stability.

9.1.2 Derailment coefficient

9.1.2.1 The derailment coefficient is used to evaluate, whether the wheel rim of the vehicle will climb up the rail head and derail, under the action of lateral force.

9.1.2.2 The derailment coefficient is the ratio of the lateral force Q , which is applied to the rail by the wheels on the rail-climbing side, to the vertical force P , which is applied to the rail, that is, the derailment coefficient is Q/P .

9.1.3 Wheel load reduction rate

9.1.3.1 Wheel load reduction rate is another derailment safety index, for evaluating derailment, which is caused by excessive reduction of wheel load.

9.1.3.2 The wheel load reduction rate is the ratio, of the wheel load reduction ΔP to the average static wheel weight $\bar{P}$ of the axle, that is, the wheel load reduction rate is $\Delta P/\bar{P}$.

9.1.4 Wheelset lateral force

The wheelset lateral force H is used to assess, whether the track gauge will be widened OR the route will be severely deformed, due to excessive lateral force, during the operation of the vehicle.

9.1.5 Lateral stability

Lateral stability is used to evaluate, whether the bogie has a continuous lateral oscillation, that cannot be damped quickly. It is evaluated by the lateral vibration acceleration α_{jy} of the bogie frame.

10.1.2 Assessment of lateral stability

10.1.2.1 Sampling method

Carry out real-time continuous sampling of the vibration acceleration of the frame above the axle box.

10.1.2.2 Data processing method

The lateral stability is evaluated, within the range of the maximum test speed $v_{\max}$. Perform the band-pass filtering at 0.5 Hz ~ 10 Hz.

10.1.2.3 Assessment of lateral stability

When the acceleration peak reaches or exceeds 8 m/s^2 for more than 6 consecutive times, it is determined that the bogie is laterally unstable.

10.2 Assessment of operational quality

10.2.1 Measurement and data processing methods

The operational quality is evaluated, within the range of the maximum test speed $v_{\max}$. Refer to Appendix D, for the measurement and data processing methods.

10.2.2 Assessment method

The calculated statistical assessment value shall be less than the assessment limit value, which is specified in 10.2.3.

10.2.3 Assessment of operational quality

The assessment limits of operational quality are as follows, according to passenger trains, EMUs, freight trains, locomotives:

- a) Passenger trains and EMUs: $\alpha_{tz} \leq 2.5 \text{ m/s}^2$, $\alpha_{ty} \leq 2.5 \text{ m/s}^2$;
- b) Freight trains: $\alpha_{tz} \leq 5.0 \text{ m/s}^2$, $\alpha_{ty} \leq 3.0 \text{ m/s}^2$;
- c) Locomotive: $\alpha_{tz} \leq 3.5 \text{ m/s}^2$, $\alpha_{ty} \leq 2.5 \text{ m/s}^2$.

10.3 Assessment of operational stability

10.3.1 Stability index

10.3.1.1 The stability index W is evaluated, within the range of the maximum operating speed V_{opr} . Refer to Appendix E, for the measurement and data processing methods.

Appendix C

(Informative)

Measurement of wheel-rail interaction force

C.1 Overview

The wheel-rail interaction force is measured by a force-measuring wheelset. The force-measuring wheelset is a special sensor, for measuring wheel-rail interaction force. Usually, strain gauges are arranged on the wheel web of the force-measuring wheelset, to form a measuring bridge.

C.2 Factors to be considered in the design of the force-measuring wheelset

The following factors shall be considered when designing the force measuring wheelset:

- a) The indexing lines of the left and right wheel bridges shall be coincident;
- b) The output of the vertical force bridge and the lateral force bridge, shall have higher sensitivity and lower influence coefficient;
- c) It shall eliminate the mutual influence of vertical force and lateral force output;
- d) Effectively eliminate the influence of the position of the wheel-rail action point;
- e) Effectively eliminate the influence of thermal stress;
- f) Effectively eliminate the influence of centrifugal inertia force.

C.3 Calibration of force-measuring wheelset

C.3.1 The force-measuring wheelset shall be calibrated on a dedicated calibration test bench.

C.3.2 The vertical force and lateral force are respectively loaded, step by step. The vertical calibrated load shall not be less than 1.5 times the weight of the static wheel. The lateral calibrated load shall not be less than 1.2 times the weight of the static wheel. At the same time, record the output of the loading force AND the force-measuring wheelset's bridge path.

C.3.3 After the calibration of the force-measuring wheelset, calculate the proportional coefficients K_{pp} and K_{qq} of the vertical force and the lateral force,

Appendix D

(Normative)

Statistical processing method of operational stability and operational quality data

D.1 Test segment

The dynamics test of complete rolling stock shall generally be carried out, in different line segments, which include:

- a) Straight-line;
- b) Large radius curve;
- c) Small radius curve;
- d) Laterally pass the turnout;
- e) Straightly pass the turnout, etc.

D.2 Statistical processing

D.2.1 Processing of each sampling segment

D.2.1.1 Processing of assessment values, such as derailment coefficient, wheel load reduction rate, wheelset lateral force

Calculate all valid sampling data on the sampling segment; THEN, perform 2 m sliding average processing.

For each sampling segment, take the 99.85% value, which is corresponding to the cumulative frequency curve of the absolute value of the sampling data, as the sample x_i of each sampling segment.

D.2.1.2 Processing of operational quality assessment values α_{ty} and α_{tz}

The operational quality assessment values, α_{ty} and α_{tz} , are calculated and processed as follows:

- a) For rolling stocks, passenger trains, EMUs, use 0.4 Hz ~ 40 Hz for band-pass filtering. For freight trains, use 0.4 Hz ~ 15 Hz for band-pass filtering.
- b) Calculate the absolute value of the maximum value x_{imax} and minimum value x_{imin} of acceleration, in the sampling segment. Each value serves as a statistical sample.

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